APPENDIX – 2-I
Screening Evaluation Methodology and Criteria

Contents:

Evaluation Methodology and Criteria Summary Table

Methodology Excerpts from the following reports:

- **The Statewide Alignment / Screening Evaluation Methodology**
- **The Bay Area to Merced Screening Evaluation**
- **The Sacramento to Bakersfield Screening Evaluation**
- **The Bakersfield to Los Angeles Screening Evaluation**
- **The Los Angeles to San Diego via Inland Empire Screening Evaluation**
- **The Los Angeles to San Diego via Orange County Screening Evaluation**

Summary Table: Evaluation Methodology and Criteria (units evaluated)

Objective	Criteria	Screening Method	Regional Applications/Variances				
			Bay Area to Merced	Sac to Bake	Bake to LA	LA to SD Inland Empire	LA to SD Orange County
Maximize Ridership/Revenue Potential	▪ Travel Time ▪ Length ▪ Population/Employment Catchment	▪ Minutes ▪ Kilometer ▪ # of persons	▪ Minutes ▪ Miles/km ▪ Qual.	▪ Minutes ▪ Miles/km ▪ Qual.	▪ Minutes ▪ Miles/km ▪ Qual.	▪ Minutes ▪ Miles/km ▪ Qual.	▪ Minutes ▪ Miles/km ▪ Qual.
Maximize Connectivity and Accessibility	▪ Intermodal Connections	▪ Qual.	▪ Qual.	▪ Qual.	▪ Qual.	▪ Qual.	▪ Qual.
Minimize Operating and Capital Costs	▪ Length ▪ Operational Issues ▪ Construction Issues ▪ Capital Cost ▪ Right-of-Way Issues/Cost	▪ Kilometer ▪ Qual. ▪ Qual. ▪ Dollars ▪ Dollars	▪ Miles/km ▪ Qual. ▪ Qual. ▪ Dollars ▪ Qual.	▪ Qual. ▪ Qual. ▪ Qual. ▪ Dollars/Qual. ▪ Qual.	▪ Miles/km ▪ Qual. ▪ Qual. ▪ Dollars ▪ Qual.	▪ Miles/km ▪ Qual. ▪ Qual. ▪ Dollars/Qual. ▪ Qual.	▪ Miles/km ▪ Qual. ▪ Qual. ▪ Dollars/Qual. ▪ Qual.
Maximize Compatibility with Existing and Planned Development	▪ Land Use Compatibility and Conflicts ▪ Visual Quality Impacts	▪ Identify Incompatible/ Conflicting Land Uses ▪ Identify location and type	▪ List Incompatible/ Conflicting Land Uses ▪ Identify location and type	▪ % of alignment option with conflicting land uses ▪ # of scenic corridor and river crossings	▪ List Incompatible/ Conflicting Land Uses ▪ Identify location and type	▪ List Incompatible/ Conflicting Land Uses ▪ Identify location and type and characterize alignment	▪ List Incompatible/ Conflicting Land Uses ▪ Identify location and type
Minimize Impacts to Natural Resources	▪ Water Resources ▪ Floodplain Impacts ▪ Wetlands	▪ # of crossings ▪ # and length of crossings ▪ # of crossings and sensitivity	▪ # of crossings ▪ # and length of crossings, and % of length in floodplain ▪ # and list of crossings and sensitivity	▪ # of crossings ▪ # and length of crossings, and acres of encroachment ▪ # of crossings and acres of encroachment	▪ # of crossings and sensitivity ▪ Identify crossings/encroachments ▪ # of crossings and sensitivity	▪ # of crossings and sensitivity ▪ # and list of crossings ▪ # of crossings and sensitivity, including vernal pools	▪ # of crossings ▪ # of floodplains ▪ # of crossings and list of crossings

Objective	Criteria	Screening Method	Regional Applications/Variances				
			Bay Area to Merced	Sac to Bake	Bake to LA	LA to SD Inland Empire	LA to SD Orange County
	▪ Threatened & Endangered Species Impacts	▪ Identify and list species	▪ Identify and list species and M^2 impacted	▪ Identify and list species and acres of habitat	▪ Identify and list species	▪ Identify and list species	▪ Identify and list species
Minimize Impacts to Social and Economic Resources	▪ Environmental Justice Impacts (Demographics) ▪ Farmland Impacts	▪ Identify areas where minority or low-income pop. Exceeds 50 % of the total pop. ▪ Acres of prime, unique, or farmland of Statewide importance	▪ # of block groups and # of people ▪ M^2 of prime, unique, or farmland of Statewide importance	▪ # of people (minority pop.) and # of households (low income pop.) ▪ Acres of prime, unique, or farmland of Statewide importance	▪ # of people (minority pop.) and # of households (low income pop.) ▪ Identify areas of impact	▪ Identify areas where minority or low-income pop. Exceeds 50 % of the total pop and qual. comp. ▪ Acres of prime, unique, or farmland of Statewide importance	▪ # of people (minority pop.) and # of households (low income pop.) ▪ # of parcels
Minimize Impacts to Cultural Resources	▪ Cultural Resources Impacts ▪ Community and Neighborhood Impacts ▪ Parks & Recreation/Wildlife Refuge Impacts	▪ # of resources and identify each ▪ Identify areas that will be divided or disrupted ▪ # of resources and identify each	▪ # of resources and identify each ▪ Qual. – part of Land Use Compatibility/ Conflicts ▪ # of resources and identify each	▪ # of resources and identify each ▪ Qual. – part of Land Use Compatibility/ Conflicts ▪ # of resources and acres	▪ # of resources and identify each and qual. Description of potential areas of concern ▪ Qual. – part of Land Use Compatibility/ Conflicts ▪ # of resources and identify each	▪ # of resources and identify each ▪ Qual. – part of Land Use Compatibility/ Conflicts ▪ # of resources and identify each	▪ # of resources and identify each ▪ # of comm. and neighbor-hood impacts ▪ # of resources and identify each
Maximize Avoidance of Areas with Geologic and Soils Constraints	▪ Soils/Slope Constraints ▪ Seismic Constraints	▪ Identify area (M^2) ▪ # of resources and discuss each	▪ Identify area (M^2) ▪ Identify faults and nature of crossing	▪ N/A ▪ N/A	▪ Identify Constraints ▪ Identify faults and nature of crossing	▪ Identify Constraints ▪ Identify faults and nature of crossing	▪ Identify Constraints ▪ Identify faults and nature of crossing

Objective	Criteria	Screening Method	Regional Applications/Variances				
			Bay Area to Merced	Sac to Bake	Bake to LA	LA to SD Inland Empire	LA to SD Orange County
Maximize Avoidance of Areas with Potential Hazardous Materials	▪ Hazardous Materials/Waste Constraints	▪ # of resources	▪ N/A	▪ N/A	▪ # of resources	▪ # of resources	▪ # of resources

**'Qual.' Refers to criteria that is analyzed and/or presented qualitatively.*

Section 4.0 of the Statewide Alignment/Station Screening Evaluation Methodology

4.0 ALIGNMENT/STATION SCREENING EVALUATION

As part of previous studies, a number of alignment options and general station locations were studied and evaluated. Many of the options considered were deemed non-viable or significantly inferior to other options considered, due to their individual physical and environmental constraints, performance, cost and potential impacts. A number of specific alignment and station location options remain within the generally defined corridors described in the previous chapter. These options, as well as other options which arise during the screening process, will need to be evaluated at a planning level and screened to identify the most viable options for more detailed study as part of the Program EIR/EIS. This screening evaluation will be based on key objectives of the system and is consistent with the design parameters and evaluation criteria applied in the previous Corridor Evaluation completed in December 1999.

4.1 EVALUATION OBJECTIVES AND CRITERIA

A number of key objectives and criteria have been established for application to this alignment and station screening evaluation. While the objectives and criteria listed in Table 4.1-1 are primarily based on previous corridor evaluation studies for the purposes of consistency, they have been enhanced to reflect the performance goals and criteria described in Chapter 2.0, as established by the Authority for this project. The objectives and criteria are divided into two main categories of engineering and environmental as summarized in the table below and described in the following sections.

Table 4.1-1
High-Speed Train Alignment/Station Evaluation Objectives and Criteria

Objective	Criteria
Maximize Ridership/Revenue Potential	▪ Travel Time ▪ Length ▪ Population/Employment Catchment
Maximize Connectivity and Accessibility	▪ Intermodal Connections
Minimize Operating and Capital Costs	▪ Length ▪ Operational Issues ▪ Construction Issues ▪ Capital Cost ▪ Right-of-Way Issues/Cost
Maximize Compatibility with Existing and Planned Development	▪ Land Use Compatibility and Conflicts ▪ Visual Quality Impacts
Minimize Impacts to Natural Resources	▪ Water Resources ▪ Floodplain Impacts ▪ Threatened & Endangered Species Impacts
Minimize Impacts to Social and Economic Resources	▪ Environmental Justice Impacts (Demographics) ▪ Farmland Impacts
Minimize Impacts to Cultural Resources	▪ Cultural Resources Impacts ▪ Parks & Recreation/Wildlife Refuge Impacts
Maximize Avoidance of Areas with Geologic and Soils Constraints	▪ Soils/Slope Constraints ▪ Seismic Constraints
Maximize Avoidance of Areas with Potential Hazardous Materials	▪ Hazardous Materials/Waste Constraints

4.2 ENGINEERING EVALUATION CRITERIA

The engineering evaluation criteria focus on cost and travel time as primary indicators of engineering viability and ridership potential. For instance, if capital costs are appropriately estimated addressing a comprehensive list of cost elements, the cost estimates will reflect the level of physical constraints and construction difficulty associated with a particular alignment or station option as well as the general viability of that option. Likewise, estimated travel times indicate the differences in potential ridership, when compared among various alignment and station options.

Items such as capital, operating and maintenance costs and travel times can be quantified for each of the alignment and station options considered. Methods and assumptions for measurement and evaluation of these criteria are described in this section.

Other engineering criteria such as operational, construction and right of way issues need to be identified and presented in a qualitative manner for each of the options to provide context for the evaluation. Any condition that poses a significant constraint or opportunity for the operation and/or construction of a high-speed train system should be identified and described for each alignment and station option.

4.2.1 Ridership/Revenue Potential

The development of ridership and revenue forecasts for each of the alignment and station options is beyond the scope and timeframe of this screening evaluation. Two items will be measured to indicate the relative ridership and revenue potential of each alignment and station options. Travel time will be estimated to indicate the relative attractiveness of alignment options. The population and employment within the reasonable catchment area will be quantified in indicate the potential ridership of each station option.

A. TRAVEL TIME ESTIMATING

Travel times should be estimated for each of the alignment options based on alignment geometry, top speed assumptions and general train performance characteristics. Specifically, the travel time estimates should account for acceleration and deceleration capabilities of each technology and the ability of each technology to maintain passenger comfort criteria through horizontal and vertical curves. Speed degradation on sustained vertical grades has been estimated based on simulations to verify and validate the results of the travel times estimated in previous corridor evaluation studies. Travel time estimating worksheets have been developed by the Program Manager as part of previous studies and will be provided for application in this screening evaluation. The travel time worksheets contain top speed assumptions and acceleration/deceleration rates and formulas. An example travel time worksheet is shown below in Table 4.2-1. Travel time worksheet files are included in Appendix B for use by the Regional Teams in this screening evaluation.

Travel times should be estimated for both technologies for both local and express service. For dwell times at intermediate stations, two minutes per station stop was assumed. All train running times include a six-percent "schedule recovery time" based on European high-speed train practice.

Travel times should be estimated and reported in the evaluation tables on an express basis between station endpoints of each segment being evaluated. Travel times should also be estimated between each intermediate station (stations between the segment endpoints) for use in verifying overall segment estimates and answering public/agency questions on the screening results. These intermediate travel time estimates should be included in the travel time estimating worksheet in the appendix materials of the regional screening evaluation report.

Table 4.2-1
Example Travel Time Worksheet

Segments			Local Travel Time							Express Travel Time					
Stations		Length	Max V	Ta	Tv	Td	Tss	Tt*	Avg V	Max V	Ta	Tv	Td	Tt*	Avg V
Begin	End	km	km/h	min	min	min	min	min	km/h	km/h	Min	min	min	min	km/h
SD	MM	16.1	250	2.7	1.4	2.2	0.0	6.7	145	250	2.7	2.5	0.0	5.5	175
MM	Esc	23.7	250	2.7	3.3	2.2	2.0	10.7	133	250	0.0	5.7	0.0	6.0	236
Esc	Tem	47.1	325	3.5	5.5	2.9	2.0	14.7	192	325	0.0	8.7	0.0	9.2	307
Tem	Riv	60.5	325	3.5	8.0	2.9	2.0	17.3	210	325	0.0	11.2	0.0	11.8	307
Riv	Ont	28.8	250	2.7	4.5	2.2	2.0	12.0	144	250	0.0	6.9	0.0	7.3	236
Ont	ESG	25.9	250	2.7	3.8	2.2	2.0	11.3	138	250	0.0	6.2	0.0	6.6	236
ESG	LA	40.6	250	2.1	10.2	1.8	2.0	17.1	142	200	0.0	11.3	1.8	13.8	176
Total Length =		**242.6**	Total Travel Time (min) =					**89.8**		Total Travel Time (min) =				**60.3**	

Notes:
- Ta – acceleration time
- Tv – time at max velocity
- Td – deceleration time
- Tss – station stopping time
- Tt* - total travel time including 6% schedule recovery

SD – San Diego; MM – Mira Mesa; Esc – Escondido; Tem – Temecula; Riv - Riverside; Ont - Ontario; ESG – East San Gabriel; LA – Los Angeles

B. POPULATION/EMPLOYMENT CATCHMENT

The amount of population and/or employment within a defined area surrounding a potential station option will serve as an indicator of ridership potential. This measurement will be applicable in comparing station options a significant distance apart (> five miles [eight kilometers]). Population and employment information should be quantified based on the best available data (e.g., regional travel demand model, census data). Previous studies defined the catchment area as within a 20-mile (32.2-kilometer) radius of the station, except in cases where two stations were within 20 miles (32.2-kilometers) of each other, in which case a 10-mile (16.1-kilometer) radius catchment area was assumed.

4.2.2 Connectivity and Accessibility

Stations serve as the only point of access or connection to the proposed high-speed train system. The selection of station locations is one of the key considerations that will affect the relative effectiveness and efficiency of the proposed high-speed train service. The number of and spacing between stations and local access to these sites are critical to the trade-off between system accessibility to riders and line haul travel time. The location of the stations with respect to travel markets and transportation infrastructure, the ease and availability of intermodal access to and from the station, and the travel time to and from the station can be critical determinants of system performance. Each of these factors should be considered and described qualitatively as part of the evaluation of each station location option. These factors should be quantified to the extent possible at this conceptual level of detail to support the qualitative discussion. Specifically, number of intermodal connections available and their proximity to the station option should be quantified at each station option considered.

4.2.3 Capital Cost Estimating

Capital cost estimating should follow the methods and assumptions defined and applied in the previous corridor evaluation. In that study, the capital costs were categorized into discrete cost elements. In general, the capital costs were estimated by determining the appropriate unit costs for the identified cost elements and the cost element quantities from conceptual high-speed train alignment plans. Each cost element is defined below along with the methods and assumptions applied in each case. Many of these elements have recently been reviewed as part of the Peer Reviews of the Corridor Evaluation commissioned by the Authority. Some of the assumptions contained herein may be revised prior to the detailed evaluation of alternatives in the next stage of this program. However, application of these assumptions will be consistent with past evaluations and will provide appropriate level of detail for the comparison of alignment and station options at this screening level.

Capital costs should be estimated and reported between station endpoints of each segment being evaluated. Capital costs should also be estimated between each intermediate station (stations between the segment endpoints) and intermediate nodes (branching/joining points for alignment options between the segment endpoints) for use in verifying overall segment estimates and answering public/agency questions on the screening results. These intermediate capital cost estimates should be included in the appendix materials of the regional screening evaluation report.

A. ALIGNMENT COSTS

Track and Guideway Items

High-Speed Train Track/Guideway: for steel-wheel-on-steel-rail systems (VHS), this includes ballast, subballast rails, ties, fasteners, and special trackwork (turnouts, sidings, etc.). For maglev systems, this consists of the guideway beams including glide surfaces, guidance rails, and stator packs (electrically powered linear motor built directly into the guideway which generates the propulsion for the maglev system). The track required in the maintenance and service facilities, as well as the at-grade or elevated reinforced concrete substructures/foundation guideway costs, including switches, within maintenance and service facilities are included in the cost of the those facilities.

Track/guideway unit costs were applied per unit length of alignment. For the train technologies, separate unit costs were applied to account for lengths of ballasted track section and direct fixation (slab track). Separate unit costs were applied to account for maglev at-grade and elevated guideway construction. Special trackwork costs were estimated based on the length of the segment and the need for special track/guideway features, such as turnouts, crossovers, etc. Special trackwork costs were estimated at 15 percent of total track/guideway costs.

Earthwork and Related Items

Included in the detailed categories below are all the earthwork elements and other items related to site development.

Site Preparation: the costs for "clearing and grubbing" which cover the removal of unsuitable surface debris, and removal of vegetation. This also includes the cost of "grading" which is the movement of dirt around the site to prepare the surface for construction. Site preparation also includes work done to make the site usable after the demolition of existing structures.

Unit costs for site preparation were applied to the total area required for earthwork operations along a given segment. The amount of area was based on the earthwork volume calculations.

Earthwork: the general category of "earthwork" is made up of four constituent activities: excavation, embankment, spoil, and borrow. Earthwork incidental to the construction of a structure, such as the excavation for a bridge foundation, would not be included here -- that cost is a part of the structural estimates.

Unit costs of earthwork were applied to the total volume of earthwork required along a given segment. A digital terrain model was used to calculate the earthwork volumes based on the profile of each segment.

Landscaping: for areas alongside the tracks/guideways within the high-speed train right-of-way. Plantings in station areas are included under passenger stations. The landscaping along the route includes the seeding of cut slopes and embankments.

Fencing: a security chain link fence 8 feet (2.5 meters) in height along the right-of-way. All at-grade sections, cut and fill sections, tunnel portals, maintenance areas, and any other areas where tracks are accessible to public will be fully fenced. A unit cost for fencing was applied per length of alignment.

Drainage Facilities: includes culverts and other structures needed for track/guideway and cross drainage purposes only, including track underdrains if needed. This does not include the cost of bridges or bridge drainage costs. The cost of drainage facilities was estimated at five percent of the cost of earthwork for each segment.

Structures, Tunnels and Walls

Structures are defined as those appurtenant elements that require structural engineering for system design, and fall into the categories below. Buildings (such as passenger terminals and maintenance facilities) are not included under structures but are in other elements.

Viaducts and Bridges: costs for prestressed reinforced concrete aerial structures include the bridge, as well as the abutment (for a bridge or viaduct). Cost for that bridge would consist of the excavation for the abutment including all wing walls and transition slabs. The foundation work would also be included as well as the earthwork needed to construct the foundations. Waterway crossings that were calculated on a per crossing basis are included under bridge costs.

It should be noted that in California a similar structural section is expected to be required for both maglev and VHS technologies -- since aerial structure design for both are controlled by the same seismic loading combination, accessibility, and serviceability requirements. In geographical areas of lower seismicity (outside our study area), other loading combinations (e.g., live load) may control. Under those conditions, the lower live load of maglev vehicles over rail vehicles may result in a reduction of construction costs for aerial structures.

A unit cost was applied per length of aerial structure. Different unit costs were used for standard aerial guideway and special structures requiring spans greater than 120 feet (36.6 meters), and for heights exceeding 30 feet (9.1 meters).

High-Speed Train Tunnels: tunnel boring machine (TBM) and drill and blast (D&B) tunnels constructed beneath the ground level that only require surface occupation (construction access) at the openings of the tunnel. The costs for these tunnels for the high-speed train system include all structural work, ventilation systems, electrical systems related to tunnel (such as lighting, fans, etc.), special drainage, etc. needed to make the tunnel ready to receive the railroad. This item does not include the track, signaling or traction power systems. Unit costs were applied per length of single and double track tunnel sections.

Seismic Chambers: an oversized tunnel segment to accommodate track realignment and passage of the train subsequent to a major fault rupture event where an especially large displacement is expected.

Retaining Walls: used to support embankments and retained fill along cut sections (retaining walls that are a part of abutments for bridges are included in the bridge costs).

Crash Walls: structural walls (including foundations and walls) required to prevent incursion of vehicles from one area to another. Generally, they are included whenever the high-speed train track/guideway is at-grade and adjacent to (within 30 feet [9.1 meters]) existing freight and passenger rail operations on dedicated portions of the high-speed train line (or alternative). Crash walls are also required adjacent to existing structures where prescribed by horizontal clearances (Ref. Caltrans Bridge and American Railway Engineering and Maintenance-of-Way Association [AREMA] Standards).

Sound Walls: walls used only for sound mitigation, including all foundations and appurtenances needed for their support. Sound walls are included in segments where adjacent land uses warrant their use. For a given segment, the amount of sound wall required was based on the percentage of developed land uses along that segment. This sound mitigation cost (cost of walls/mile [walls/meter]) was estimated separately from, and in addition to, the environmental mitigation cost (factor of line construction cost).

Grade Separations

Bridges and Undercrossings: highway and railroad overcrossings/undercrossings of the high-speed train system. All crossings with other transportation facilities must be grade-separated from the high-speed train system. The unit costs applied for these grade separations include all of the cost elements necessary to complete the construction of the grade separations, such as earthwork, traffic handling, drainage, etc. The number of existing crossings (roadway and rail) per segment was quantified per USGS planimetric information, field reconnaissance and other mapping sources according to type (at-grade, under or over) and size (primary, secondary and minor roadways). Judgments were made regarding the proposed crossing type, including the option of closure for minor roadways, and costs were calculated on a per-crossing basis.

Building Items

Passenger Stations: platforms, circulation, lighting, security measures and all auxiliary spaces including intermodal connection areas. Spaces are provided within the station for ticket sales, passenger information, station administration, baggage handling, and a reasonable amount of commercial space for newsstands, restaurants, etc. Different station facility unit costs were applied to four separate station classifications: terminal, urban, suburban and rural. The different unit costs account for differences in station size, configuration and general location. These costs are assumed to be a rough average, since station costs are expected to vary widely at specific locations.

These average station costs per category will not be useful in the comparison of station options in this screening evaluation. Since the size requirements of the stations do not vary per specific station location option, the right-of-way costs and major physical constraints will be the key differentiating factors in the comparison of individual station location options. Regional Teams should apply local right-of-way cost information as the primary cost comparison factor for this screening effort. Major physical constraints should be identified and the associated effects on capital cost should be discussed qualitatively and quantified to the extent possible. More detailed station construction unit costs will be applied in subsequent evaluations.

Site Development & Parking: the paving, parking structures and landscaping of the site around the passenger station building. Also included is the provision of street and roadway modifications necessary to provide access to the site. Different site development unit costs were also applied to the four station classifications: terminal, urban, suburban and rural.

Rail and Utility Relocation

Railroad Relocation: the cost of track relocations (temporary or permanent) required to place high-speed train track/guideway into existing rail corridors, including all construction work needed to relocate the railroad, including earthwork, trackwork, etc. A unit cost was applied to the length of alignment requiring relocation.

Utility Relocation: the cost of major utility relocations that must be done before constructing the facilities, such as: overhead power lines, pipelines, sewers and fiberoptics and underground ductbanks. Different unit costs were applied to the total length of alignment based on the intensity of land use development along the alignment.

B. RIGHT-OF-WAY ITEMS

The total cost associated with the purchase of land and/or easement rights for the high-speed train system. This includes relocation assistance and demolition costs. Property values and acquisition costs can range from quite modest in undeveloped areas, to quite significant in areas where high-value commercial properties near the stations are needed. In some cases, the cost of acquisition services may equal or exceed the cost of the property itself. These costs include those for title searches, appraisals, legal fees, title insurance, surveys, and various other processes.

The cost estimates assume that a minimum right-of-way width of 50 feet (15.2 meters) is necessary throughout the length of each segment. Even when the alignment is primarily within existing rail rights-of-way, costs are estimated to account for the purchase and or lease agreements necessary for operation in these corridors. Wider right-of-way sections are necessary in mountainous areas where large cut and fill slopes are required.

Three general parameters were followed: (1) a minimum right-of-way corridor of 50 feet (15.2 meters) has been assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor has been assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes.

The Regional Teams should review the unit costs applied in the previous study realizing that they were applied on an overall average basis. For the purposes of this screening, right-of-way unit costs should be revised as necessary in each region to reflect local market conditions.

C. ENVIRONMENTAL IMPACT MITIGATION

This cost is total cost associated with mitigation of environmental impacts such as wetland replacement, parkland mitigation, and biological resource/habitat replacement or enhancement.

Noise mitigation with sound walls and right-of-way impact and relocation mitigation are estimated separately as defined above.

The total cost of environmental mitigation was estimated to be three percent of the line construction costs (i.e. track, earthwork, structures, etc.) for each segment, based on other recently implemented transportation corridors in California. The environmental mitigation cost per length of track/guideway is anticipated to be the same for both VHS and maglev systems.

This factor is applied on the average to estimate a total cost of mitigation. It is not useful as a distinguishing factor in the screening evaluation. The potential environmental impacts are evaluated as part of the environmental criteria in Section 4.3.

D. SYSTEM ELEMENTS

Signaling and Communications Items

Signaling: These costs cover the cost of wayside, on-board and central control software and hardware for the overall signaling system. The unit costs are applied per length of track/guideway. The VHS technologies operate either on the basis of moving block technology with automatic train protection (ATP) or automatic train control (ATC) and automatic train operation (ATO).

Communications: includes a high capacity fiber optic backbone with full redundancy, which is key for the operation of the Supervisory Control and Data Acquisition (SCADA) and reliable ATC systems. The communication system will be used for operations; maintenance and emergencies; phone and fax capabilities (enroute); closed circuit television; public information systems; public address systems; and other monitoring and detection devices needed for a safe and efficient operating system. The unit costs are applied per length of track/guideway.

Wayside Protection Systems: includes systems/equipment to monitor and/or detect obstacles that may be placed or fall onto the track/guideway; intrusion; flooding; wind; seismic activity and equipment failures (broken rails, hot axles, dragging equipment, etc.). The unit costs are applied per length of track/guideway.

Electrification Items

Traction Power Supply: This cost is the entire cost of the substations, including site preparation; foundations; cable trenches; fencing; electrical equipment, etc. The unit costs are applied per unit length of track/guideway. It does not include the cost of transmission lines from the local utility source to the substations; those are included in the energy costs, a part of the operating and maintenance costs. These costs are different for VHS and maglev.

Traction Power Distribution: This cost is for VHS systems, which includes the catenary poles and foundations; the catenary wires and supports; tensioning devices; power feeders and returns; transformers and other appurtenances. For maglev systems, it includes the power transmission cables and control equipment along the guideway as well as the 3-phase longstator cable windings (mounted in the stator packs on the underside of the guideway). The unit costs are applied per unit length of track/guideway.

E. VEHICLE AND SUPPORT FACILITY COSTS

The capital costs associated with vehicles and support maintenance facilities will not be included in this screening evaluation. They will be addressed in the next stage of this program.

F. PROGRAM IMPLEMENTATION COSTS

Costs for these elements are computed as a percentage of the total of construction and procurement costs. The percentages are intended to represent the average overall cost of these implementation items, based on implementation of rail transit and other related improvement projects throughout the state. The percentages are predicated on a Design-Build (DB) and Design-Build-Operate-and-Maintain (DBOM) procurement approach and would be significantly higher using a traditional procurement approach. These costs would be divided between the owner and the contractor in this procurement approach and are noted accordingly. These costs are not useful in the screening evaluation; however, they should be maintained in the cost estimates for overall consistency in the order of magnitude.

<u>Preliminary Engineering and Environmental Review</u>

These are preliminary engineering design costs to approximately a 35 percent level. This will include geotechnical investigations; land surveying and mapping; engineering; architecture; landscape architecture; traffic engineering; right-of-way engineering and preparation of preliminary plans and analyses in all necessary technical disciplines; and various other technical studies and support of the draft environmental document. The environmental review would entail all studies and analyses necessary to complete both federal and state required environmental documents. (Owner - 2.5 percent)

<u>Program & Design Management</u>

Costs for the overall management and administration of the project. Included were the Program Manager's office, contract management and administration, project control including both cost and schedule, general administration, computer support, quality assurance, configuration management, system safety, publications, public relations, support of the bidding process, agency liaison, community information and involvement and legal support. (Owner - 5.0 percent)

<u>Final Design</u>

Costs for final design and preparation of construction and procurement documents for all facilities and systems. This will include geotechnical investigations; land surveying and mapping; engineering; architecture; landscape architecture; traffic engineering; right-of-way engineering; preparation of plans and specifications in all necessary technical disciplines; and various other technical studies and support of the final design process. Design support during construction, including shop drawing review is also included in this item. (Contractor - 5.0 percent)

<u>Construction & Procurement Management</u>

Costs for all management of construction and procurement work after contracts are awarded to contractors or suppliers. This will include on-site inspection in factory and field, quality control, contract administration and acceptance inspection. (Owner – 1.0 percent; Contractor – 4.0 percent)

Agency Costs

The costs of maintaining the owner's organization during the entire program, whether that owner is a franchisee or a government agency. (Owner - 1.0 percent)

Force Account Costs

Costs for the services of other organizations or agencies of local, state or federal government that may be required to support the project. Work within railroad rights-of-way may be on force account with the appropriate railroad. There may be unforeseen costs as a result of moving the railroad to allow for high-speed trains. (Owner - 1.0 percent)

Risk Management

The costs of owner-supplied insurance or any other allowances decided to be applied for the management of risk to the owner. (Owner - 6.0 percent)

Testing & Pre-Revenue Operations

The costs of pre-revenue testing, acceptance testing, safety certification and training related to start-up of the system for revenue service. These costs would be included in the DBOM contract. These costs are not included as part of the program implementation costs for this screening evaluation.

G. CONTINGENCIES

A contingency is added as a percentage of overall project costs -- based on past experience for projects in early stages of definition. Contingencies should not be considered as potential savings. They are an allowance added to a basic estimate to account for items and conditions that cannot be assessed at the time of the estimate. The contingency amount is expected to be reduced as the project matures. The contingency is estimated at 25 percent of the total of construction costs.

H. UNIT COSTS

Unit costs were developed for each cost element described above. The unit costs are presented by cost element in Appendix C.

4.3 ENVIRONMENTAL EVALUATION CRITERIA

The environmental constraints and impacts criteria, while meeting the objectives outlined in Table 4.1-1, will focus on environmental issues that can affect the location or selection of alignments and stations. These are organized into five overall environmental categories as outlined below.

Table 4.3-1
Environmental Evaluation Criteria

Category	Criteria
Land Use	▪ Land Use Compatibility and Conflicts ▪ Visual Quality Impacts
Natural Resources	▪ Water Resources Impacts ▪ Floodplain Impacts ▪ Wetlands Impacts ▪ Threatened & Endangered Species Impacts
Social and Economic Resources	▪ Environmental Justice (Demographics) ▪ Community & Neighborhood Impacts ▪ Farmland Impacts
Cultural Resources	▪ Cultural Resources Impacts ▪ Parks & Recreation/Wildlife Refuge Impacts
Engineering and Environmental Constraints	▪ Soils/Slope Constraints ▪ Seismic Constraints ▪ Hazardous Materials/Waste Constraints

In addition to the environmental issues listed above, Regional Teams may identify other issues that could affect the location and selection of alignments and stations specific to their regional study area. In those cases, each Regional Team should document the reasons for evaluation and the methodologies employed in the regional High-Speed Train Alignments/Stations Screening Evaluation report.

To identify potential impacts for the alignments and station locations, a number of readily available baseline digital data sources were provided for use with ESRI-compatible Geographic Information System (GIS) software (ArcView v.3.2 or ArcInfo v.8.02). Digital data included SPOT 10-meter resolution satellite imagery (available for 1998-2000) and USGS Digital Raster Graphics (DRGs) (1:24,000 and 1:100,000), which may be used as base map information. Digital data specifically pertinent to each topic is identified in the methodology that follows. GIS data will be provided to the Regional Consultant Teams for use in the evaluation of alignments and stations created in a CAD/MicroStation environment. Refer to Task 1.9 – GIS Data Management Plan[10] for a complete discussion of the GIS protocols). Teams are encouraged to update/supplement the baseline data with more detailed data, if available, with the understanding that the data will be the property of the Authority at the end of the project along with Federal Geographic Data Committee- (FGDC-) compliant metadata. Additional information will have to be obtained by the Regional Teams as part of the project including general plans (all elements and community plans) from the jurisdictions traversed by the corridors and regional planning documents. All documents obtained for the project will also become the property of the Authority.

For evaluation of alignments and stations, right-of-way widths dictated by engineering requirements should be utilized (refer to Section 3.2.8). Right-of-way should be used to identify the amount of area within each segment containing certain characteristics. These segment widths should be used for the water resources, floodplains analysis; parks, recreation areas and wildlife refuges analysis; farmlands; land use compatibility analysis; and the hazardous materials/waste analysis. Other environmental issues will use various buffer widths that extend beyond the conceptual right-of-way for the segments. For consistency between regional studies, each buffer width has been identified based upon the specific

[10] Parsons Brinckerhoff. California High-Speed Train Program EIR/EIS, Task 1.9 – GIS Data Management Plan. Prepared for California High-Speed Rail Authority, February 2001.

analysis needs of the environmental issue and is described in Section 4.3.1 within each specific evaluation methodology.

While some of the evaluation can occur through the use of the data sources provided, field reconnaissance will be required to view on-the-ground conditions and to provide relative values of certain resources. Generally this field investigation will take the form of "windshield" surveys. In cases where the alignment is not generally visible from the nearby roadway network, other methods should be used, such as high-rail vehicles or aerial reconnaissance. However, "walking" the entire alignment should not be necessary at this level of analysis. The methodologies used for analyzing the potential environmental impacts are identified below.

Certain environmental regulations require a demonstration that avoidance alternatives have been evaluated when there are impacts to publicly-owned land from a park, recreation area, or wildlife or waterfowl refuge, or land from a historic site eligible for or listed on the National Register of Historic Places (Section 4[f] of the Department of Transportation Act); wetlands (Executive Order 11990); and floodplains (Executive Order 11988). According to Section 4(f) of the Department of Transportation Act, the Secretary of Transportation may approve a federal transportation project only if there is no feasible and prudent alternative to the use of such land, and; the proposal includes all possible planning to minimize harm to the Section 4(f) land resulting from such use. Executive Order 11990 (wetlands) requires federal agencies to refrain from giving financial support or other assistance to projects that will encroach upon public or private wetlands unless the agency finds that there are no reasonable alternatives to the proposed project and that the proposed project includes all reasonable mitigation recommendations to minimize the adverse effects of the project. Executive Order 11988 (floodplains) directs all federal agencies to avoid all short-term and long-term adverse impacts associated with floodplain modification and to avoid direct and indirect support of development within 100-year floodplains whenever there is a reasonable alternative available. When evaluating these three types of resources based on the limited level of information available for screening, the Regional Teams should clearly document why certain segments/stations have been screened from further evaluation.

4.3.1 Environmental Screening Methodology

A. LAND USE

Land Use Compatibility and Conflicts

Existing development throughout the state varies widely from dense urban areas to suburban areas to farmlands. Land use compatibility and conflicts include consideration of proximity impacts on adjacent land uses, such as noise, vibration, and visual impacts along segments and traffic and air quality impacts at stations. Potential land use conflicts may arise from siting a high-speed train alignment or stations within residential areas, near schools, and adjacent to parks and recreational areas among others. For this evaluation stations are considered to include the station, platforms, parking facilities, and ancillary facilities.

Utilizing the SPOT images provided in the GIS Database, digital land use data, general plans, and field reconnaissance, the Regional Teams should evaluate land use compatibility and conflicts for alignments and stations as discussed below.

Alignments:

- The best land use compatibility scenario for siting high-speed train alignments was identified to be within or along designated transportation or utility corridors. The Regional Teams need to identify the dominant general land uses within and adjacent to the proposed segment. Existing land use classifications for this evaluation should include transportation/utility corridors, recreational, open space/undeveloped, farmland, institutional (schools, hospitals, churches, libraries, military), commercial, office, industrial, and residential. In areas of mixed uses, classify as mixed use, but identify those uses that are most common.

Stations:

- The adjacent circulation network around proposed stations should be qualitatively evaluated to identify if sufficient roadway capacity exists to support the station. If not, the Regional Teams need to identify what measures may be required to handle traffic in and around proposed stations.
- Identify if the location of a station would lead to conversion of adjacent land uses that would be incompatible with general plan land uses (e.g., conversion to commercial uses in areas not planned for such uses). It should be assumed that commercial development would be induced near stations. This should be evaluated against the general plans and other policy documents to identify incompatibility. Any conflict with these policy documents would be considered potentially significant.
- Identify station locations that would provide for intermodal connections. This would be considered to be a potentially compatible land use scenario.

Visual Quality Impacts

High-speed train projects, which are typically large, linear elements that traverse various types of terrain, land use, water features, vegetation, and development, can often have a substantial visual effect. The effects can be adverse or beneficial. The public acceptance of a proposed transportation improvement is often dependent upon the public's understanding and acceptance of its visual quality effects.

The U.S. Department of Transportation developed guidelines for assessing visual impact of transportation facilities, particularly highways. The methodology applied in the evaluation of the high-speed train corridors utilized this method to identify areas where there may be the potential for visual quality impacts. The methodology considers the visual impact of high-speed trains for all viewer groups, including adjacent land users (views of the project) as well as high-speed train users (views from the train). Potential physical changes to the environment, such as cuts/fills, elevated structures, water crossings, and loss of major vegetation and urban development need to be identified. In addition, those viewers who would be sensitive to visual changes, such as residents, park users, and travelers along the proposed facility should also be identified. To conduct the evaluation, USGS DEMs should be used to identify the topography and areas of cuts, fills, tunnels, and elevated structures. GIS data gathered for other components of this study, including water crossings, populated areas, and parks and recreational resources should also be utilized.

The location and type of sensitive "first-row" viewers should be identified and overlaid on the high-speed train segments. First-row viewers are the nearest viewers that can see the alignment or other potential project elements. In urban areas, this is probably the adjacent properties, if they are sensitive (as defined above). In more open or rural areas, the first row receivers may be located some distance away. (Note: The sensitive viewers from the train should be assumed for the entire segment and do not have to be further identified.)

In addition, the location and type of potential major physical changes (cut/fill slopes, aerial structure, tunnel portals, station locations, etc.) should be identified and overlaid on the high-speed train segments. Areas with sensitive first-row receivers and potential major physical changes is the area where there is a high potential for visual impacts.

Highly sensitive visual resources that would be visible from the segments (and would, thus, have views of the segments) should be identified. These would include such resources as scenic highways, wild and scenic rivers (as defined by the Wild and Scenic Rivers Act of 1968), scenic overlooks or viewpoints, National Park land and State Park land, wilderness areas (as defined by the Wilderness Act of 1964), etc. Review local general plans and other policy documents to identify locally important visual resources.

B. NATURAL RESOURCES

Water Resources Impacts

Water resources for this stage of environmental evaluation include streams, rivers, lakes, and sensitive natural drainage basins or watersheds (surface flow). Identifying water resources is important to comply with federal and state laws requiring that these resources be identified and impacts to them avoided or minimized. High-speed train corridors should avoid or minimize effects to watersheds or natural drainage patterns. Water resources are also identified to minimize degradation of water quality.

Using the USGS hydrographic features in the GIS Database, the number of water resources crossed by a segment should be quantified to identify the level of potential impact. In urbanized areas, it is likely that many of the crossings are channelized or otherwise improved, rather than natural. Impacts would be considered greater for crossings of natural streams and rivers and watersheds compared to previously improved channels because of potential wetland and sensitive habitat impacts. The Regional Teams should delineate watersheds and drainage patterns and note the name of the water crossings (when known), whether they are natural or improved.

Floodplain Impacts

Floodplains are defined as the area subject to flooding by a 100-year flood. A 100-year flood is caused by a storm of general intensity and duration that would be expected to have a one-percent chance of occurrence in any given year.

To identify the potential location of areas within the 100-year floodplain, the Regional Teams should utilize the Federal Emergency Management Agency digital Federal Insurance Rate Maps. The number of floodplain crossings and the total length of the crossings should be quantified. The Regional Teams need to document if other segment alternatives were evaluated that may avoid or minimize impacts to floodplains. A floodplain evaluation will be part of the subsequent detailed technical studies along with a more detailed evaluation a reasonable avoidance alternatives.

Wetland Impacts

Wetlands serve important purposes relating to fish and wildlife, recreation, and other elements of the general public interest. The U.S. Army Corps of Engineers (Corps) and the Environmental Protection Agency (EPA) regulate fill of wetlands. As environmentally vital areas, they constitute a productive and valuable public resource; the unnecessary fill of wetlands or alteration should be discouraged as contrary to the public interest. Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Data from the National Wetlands Inventory (NWI) has been included in the California High-Speed Train GIS Database. Based upon NWI data availability, these maps do not provide full coverage of the entire high-speed train study area. The Regional Teams should utilize other wetlands data at their disposal and document source and date of the information used. This information should be supplemented with information on sensitive wetland habitats recorded in the California Natural Diversity Database (CNDDB). The number of wetland crossings should be quantified and the potential value of the wetlands assessed and documented (i.e., is the wetland part of a larger system of wetlands, are the wetlands part of a wildlife refuge or sanctuary, are there institutional restrictions on constructing in the wetlands). This evaluation will not identify all wetlands likely to be encountered within a segment, but rather should quantify potential for impacts to previously identified wetlands. The Regional Teams need to document if other segment alternatives were evaluated that <u>may</u> minimize impacts to wetlands (at the screening level, only the previously identified wetlands [by others] will be known and true avoidance or minimization will not be known). The Regional Teams should note any special cases where wetlands are suspected which could affect the siting of alignments or stations and discuss at a qualitative level. Wetlands delineations will be part of the subsequent detailed technical studies along with a more detailed evaluation a reasonable avoidance alternatives.

<u>Threatened and Endangered Species Impacts</u>

Protection of plant and animal species of special concern have been afforded recognition by federal, state, or local resource conservation agencies, organizations and/or jurisdictions. These include species listed as rare, threatened, and/or endangered by resource conservation agencies such as the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG).

The threatened and endangered species analysis will be based on information obtained from the California Natural Diversity Database (CNDDB), contacts with CDFG Natural Heritage Division and USFWS, information from available published literature, and existing documentation of special status species and habitats in the project area. The database is not complete or definitive, but it includes most of the species that would be required to be addressed under both the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA). The Regional Teams should identify observations of threatened and endangered species and sensitive habitat areas traversed (information on sensitive habitat areas can be obtained from the local resource agencies). Field surveys are not required for this analysis. Locations of special status species and their habitats are approximate and are subject to change as a result of seasonal variation, local land use changes including urbanization and development and other disturbances. The Regional Teams should identify and list the threatened and endangered species within the right-of-way or directly adjacent to the segments and station areas. The number of species is not important, but is an indication of potential species to be encountered. Those species or habitat that would require special mitigation or coordination with resource agencies should be documented. More detailed surveys will be part of the subsequent detailed technical studies.

C. SOCIAL AND ECONOMIC RESOURCES

<u>Environmental Justice (Demographics) Impacts</u>

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires federal agencies to take the appropriate and necessary steps to identify and avoid "disproportionately high and adverse" effects of federal projects on the health or environment of minority and low-income populations. The California High-Speed Train Project would be required to comply with Executive Order 12898. The evaluation will identify minority and low-income populations within close proximity of the corridors rather than disproportionate impacts, which will be conducted as part of detailed technical studies.

To evaluate the potential for disproportionate effects on populations, the GIS Database information from the 1990 U.S. Census (census block groups) should be used to identify low-income and minority populations within a 1,400-foot (426.72-meter) buffer. A 1,400-foot (426.72-meter) buffer (700 feet [213.26 meters] either side of the center of the right-of-way) encompasses areas that would be directly affected due to displacement from the acquisition of right-of-way, and areas outside the right-of-way that could be indirectly affected by noise, vibration, and visual.

Block groups are the smallest area for which census information has been aggregated. The boundaries for block groups have been included in the GIS database. The buffer encompasses areas that would be directly affected due to potential displacement from the acquisition of the right-of-way, and areas outside the right-of-way that could be indirectly affected by project-related noise, vibration, and other indirect effects. The first variable, percent population below the poverty level, should be based on 1989 household income and includes all persons in households with incomes below a threshold of $12,674 for a family of four. The population below the poverty level was calculated for all census block groups in the study area. The second variable included in this assessment is the population that is non-white, including Hispanic, which is a multi-racial group. Those block groups where the minority or low-income populations exceed 50 percent should be identified as areas where there may be the potential for disproportionate impacts.

<u>Community and Neighborhood Impacts</u>

Community and neighborhood impacts include disruption to neighborhoods and physical barriers or divisions of established communities that would affect those who live or work in the area.

Utilizing the SPOT images, general plans, and field reconnaissance, the Regional Teams should identify areas where segments have the potential to divide or disrupt communities or neighborhoods. Segments that extend within or adjacent to existing corridors or rights-of-way would be less likely to divide or result in barrier effects. If segments lie within a new corridor, then field review would be required to identify areas that may be divided or separated from other parts of the neighborhood or community. Also note if there is the potential to affect community resources or activity centers. The Regional Teams should identify places where facilities would be separated from the community they serve. Community resources can include police and fire stations, libraries, hospitals, recreational facilities, churches, neighborhood shopping areas, schools, and beaches, among others.

<u>Farmland Impacts</u>

Farmlands include Prime Farmland, Unique Farmland, and Farmland of Statewide Importance. Prime Farmland is that which can economically produce sustained high yields of basic crops such as food, feed, forage, fiber, and oil seed. Unique Farmland is land other than Prime Farmland or Farmland of Statewide Importance that is currently used for production of specific high value food and fiber crops. Farmland of Statewide Importance is land other than Prime Farmland that has a good combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oil seed crops.

Digital farmland mapping has been obtained from the U.S. Natural Resources Conservation Service (NCRS) (formerly the Soil Conservation Service) and uploaded into the GIS database. Potential impacts to Prime Farmland, Unique Farmland, and Farmland of Statewide Importance should be quantified by number of acres within each high-speed train segment and station location using the engineering right-of-way widths. The Regional Teams should also use the SPOT data to identify and quantify the number of locations where there are obvious divisions of farmland parcels or parcels that would become isolated and not suitable for continued farming or agricultural use.

D. CULTURAL RESOURCES

Cultural Resources Impacts

Cultural resources include historic properties, bridges, districts, and archaeological sites and sites that could be considered sacred to Native American groups. Impacts to these resources fall under several federal laws, including Section 106 of the National Historic Preservation Act and Section 4(f) of the Department of Transportation Act. These laws require consideration of effects to historic properties listed in or eligible for the National Register of Historic Places and specifically consideration of feasible and prudent avoidance alternatives under Section 4(f). In addition, CEQA requires mitigation, if feasible, of properties listed on the National Register, the California Register of Historic Resources, or otherwise identified as of local cultural importance.

Cultural resources data for the analysis were developed principally from the GIS database provided by the National Parks Service on National Register resources (please review the address provided in the GIS data and not go on the location of the point only). The California Register and any local registers should also be checked, as well as general plans and the cultural resource knowledge of team members to identify potential historic and archaeological impacts. Potential impacts to cultural resources should be identified and quantified for those resources within the high-speed train segment right-of-way width. While conducting the evaluation, cultural resources within close proximity (first row receiver [see Visual Quality Impacts discussion]) but not actually in, the assumed right-of-way that may be affected by high-speed train operation should also be identified.

Parks and Recreation/Wildlife Refuge Impacts

Section 4(f) of the United States Department of Transportation Act of 1966 affords protection to certain cultural resources and parks and recreational areas. Section 4(f) resources include publicly owned land in a public park, recreation area, or wildlife and waterfowl refuge of national, state or local significance as determined by federal, state or local officials having jurisdiction over such resource. Impacts on these resources are critical to assess because of their federal protection. Section 4(f) requires consideration of feasible and prudent avoidance alternatives and measures to minimize harm.

For this analysis parks, recreation areas, and refuges should be identified and input to the California High-Speed Train GIS Database as point information (include name, address, city, owner, type of facility), using published maps and general plans (if electronic information is unavailable). Parks, recreation areas, and wildlife refuges potentially affected should be identified and quantified by overlaying the alignment and station right-of-way. While conducting the evaluation, resources that are within dose proximity (first row receiver [see Visual Quality Impacts discussion]) but not actually in the assumed right-of-way that may be affected by high-speed train operation should be identified.

E. ENGINEERING/ENVIRONMENTAL CONSTRAINTS

Soils/Slope Constraints

Soils and slope constraints include soils with high erodibility, soils with a high propensity to shrink or swell under certain soil moisture conditions, and steep slopes (slope greater than nine percent). Avoidance of these areas is important because of safety, stability of structure concerns, construction difficulty, and cost of mitigation.

Soil data, the State Soil Geographic (STATSGO) data was obtained from the U.S. Department of Agriculture. The STATSGO data broadly identifies soil types and properties within the state, including erodibility and shrink/swell potential. The STATSGO data should be used to identify erodibility and shrink/swell potential.

Slopes can be identified in GIS using the USGS Digital Elevation Models (DEMs). Slopes are classified into five categories: 0 to 4 percent, 5 to 8 percent, 9 to 15 percent, 16 to 25 percent, and greater than 26 percent. The area of erodible soils, shrink/swell soils, and steep slopes (greater than 9 percent) within the right-of-way should be quantified for each segment.

Seismic Constraints

Identifying the location of known active seismic areas and faults is important in developing adequate high-speed train safety measures, as well as construction and operational mitigation. To do this, the distribution and nature of known active faults and potentially damaging seismogenic sources along each of the segments must be identified.

A number of data sources will have to be utilized to identify fault crossings: California Division of Mines and Geology (CDMG) and the USGS, published reports and papers, CDMG Fault Evaluation Reports, and data from the Working Group for Northern California Earthquake Potential (NCEP). The active fault crossings for high-speed train segments should be quantified and discussed. General plans and other sources should be reviewed for information about other seismic hazards that might affect the segments, such as mapped areas of liquefaction potential, landslide potential, subsidence or uplift potential, etc. If seismic information is unavailable electronically, faults crossing the high-speed train segments should be input to the GIS Database.

Hazardous Materials/Waste Constraints

Known hazardous materials/waste sites are considered constraints to be avoided. It is state policy, in the development of transportation projects, to fully consider and avoid, wherever possible, all potential aspects of hazardous materials/waste. Not only can encountering hazardous materials/waste affect the project costs and schedule, but it can also create the potential of exposure of people or the environment to hazardous materials/waste. Materials that constitute hazardous waste include petroleum products, pesticides, organic compounds, heavy metals, or other materials injurious to human health and the environment.

To evaluate the potential sites a statewide database was obtained from VISTA Information Solutions Inc. The segment right-of-way widths should be used in the hazardous materials/waste analysis. The number of potential hazardous waste sites will need to be quantified for each segment. Major sites or sites likely to require extensive remediation should be identified.

Section 2.0 of the Bay Area to Merced Alignment / Station Screening Evaluation Methodology

2.0 PARAMETERS/ASSUMPTIONS AND EVALUATION METHODOLOGY

Unless otherwise noted, the objectives, parameters, criteria, and methodologies described in this report are consistent with those applied in previous California high-speed train studies and documented in the *California High-Speed Train Program EIR/EIS*, *Task 1.5.2 – High-Speed Train Alignment/Station Screening Evaluation Methodology*.[7]

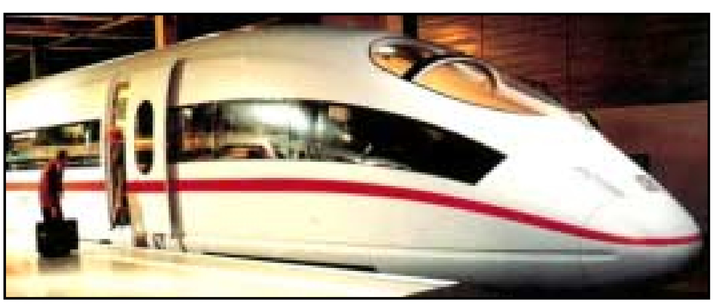
2.1 PARAMETERS/ASSUMPTIONS

High-speed train alignment and station options were developed through consistent application of system, engineering, and operating parameters as described in Task 1.5.2. The parameters and assumptions applied are consistent with those applied in previous planning and engineering studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

2.1.1 Statewide Parameters/Assumptions

The design, cost, and performance parameters used in developing the alignment and station options are based on two technology groups (classified by speed) (Figure 2.1-1). The Very High Speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 km/h) utilizing steel-wheel-on-steel-rail technology. Requirements for a VHS system include a dedicated, fully grade-separated right-of-way (ROW) with overhead centenary for electric propulsion. It is possible to integrate a VHS system into existing conventional rail lines in congested urban areas given resolution of certain equipment and operating compatibility issues. The magnetic levitation (maglev) group utilizes magnetic forces to lift and propel the train along a guideway and is designed for maximum operating speeds above that of VHS technology. A maglev system requires a dedicated guideway and may share ROW but not track with conventional train systems.

Figure 2.1-1: VHS and Maglev Technology



VHS Train (Germany ICE)

Maglev (Transrapid)

[7] Parsons Brinckerhoff. *California High-Speed Train Program EIR/EIS, Task 1.5.2 – High-Speed Train Alignments/Stations Screening Evaluation Methodology*. Prepared for California High-Speed Rail Authority, May 2001.

High-speed train system engineering design parameters used in developing the alignments were documented in Task 1.5.2 and include speeds, geometry, and clearances for both steel-wheel-on-steel-rail (VHS) and maglev high-speed train technologies. The parameters and criteria, summarized in Table 2.1-1, are consistent with previous California high-speed train studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

Table 2.1-1
Summary of Engineering Design Parameters

Parameter	Very High-Speed	Maglev
Double Track	Full	Full
Power Source	Electric	Electric
Grade Separations	Full	Full
POTENTIAL FOR SHARED USE	Yes	No
Corridor Width ❑ **Desirable** ❑ **Minimum**	 100 ft (30.4 m) 50 ft (15.2 m)	 100 ft (30.4 m) 50 ft (15.2 m)
Top Speed	220 mph (350 km/h)	240 mph(1) (385 km/h)
Average Speed	125-155 mph (200-250 km/h)	145-175 mph (230-280 km/h)
Acceleration	0.4-1.3 mph/s[3] (0.6-2.1 km/h/s[4])	1.1-1.9 mph/s (1.8-3.2 km/h/s)
Deceleration	1.2 mph/s (1.9 km/h/s)	1.8 mph/s (2.9 km/h/s)
MINIMUM HORIZONTAL RADIUS	500-650 ft (150-200 m)	1,150 ft (350 m) (2)
Minimum Horizontal Radius (at top speed)	15,600 ft @ 220 mph (4,750 m @ 350 km/h)	11,500 ft @ 240 mph (3,500 m @ 385 km/h)
Superelevation ❑ **Actual (Ea)** ❑ **Unbalanced (Eu)**	 7 in (180 mm) 5 in (125 mm)	 16° 5°
Grades ❑ **Desirable Maximum** ❑ **Absolute Maximum**	 3.5% 5.0%	 NA 10.0%
Minimum Vertical Radius Crest Curve (at top speed)	157,500 ft @ 220 mph (48,000 m @ 350 km/h)	205,700 ft @ 240 mph (62,700 m @ 385 km/h)
Minimum Vertical Radius Sag Curve (at top speed)	105,000 ft @ 220 mph (32,000 m @ 350 km/h)	137,100 ft @ 240 mph (41,800 m @ 385 km/h)
Horizontal Clearance (centerline of track to face of fixed object)	10 ft 4 in @ 220 mph (3.1 m @ 350 km/h)	9 ft 5 in @ 240 mph (2.8 m @ 385 km/h)
Vertical Clearance (top of rail to face of fixed object)	21 ft (6.4 m)	12 ft 2 in (3.7 m)
Track Centerline Spacing	15 ft 8 in @ 220 mph (4.7 m @ 350 km/h)	15 ft 9 in @ 240 mph (4.8 m @ 385 km/h)
Minimum Right-of-Way Requirements At-Grade/Cut-and-Fill/Retained Fill Aerial Structure Tunnel (Double Track) Tunnel (Twin Single Track) Trench/Box Section	 50 ft (15.2 m) 50 ft (15.2 m) 67 ft (20.4 m) 120 ft (36.6 m) 70 ft (21.3 m)	 47 ft (14.3 m) 49 ft (15 m) 67 ft (20.4 m) 120 ft (36.6 m) 73 ft (22.2 m)
Minimum Station Platform Length	1,300 ft (400 m)	1,300 ft (400 m)
Minimum Station Platform Width	30 ft (9 m)	30 ft (9 m)
Notes: 1- Top Speed Defined in Federal Maglev Deployment Plan 2- Transrapid USA, 1998. 3- mph/s – miles per hour-second 4- km/h/s – kilometers per hour-second		

Based on the minimum requirements listed in Table 2.1-1, three general ROW parameters were utilized for the screening evaluation: (1) a minimum ROW corridor of 50 feet (15.2 meters) was assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor was assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes and tunnels.

The overall operations strategy and conceptual service parameters that were assumed for high-speed train service in California are documented in Task 1.5.2. Specific scheduling and operations modeling analysis is currently underway and will be used in future detailed engineering and environmental analyses in the next phase of this study.

2.1.2 Bay Area-to-Merced Corridor Parameter/Assumption Variances

Variances to the state-wide parameters and assumptions described above were applied for the Bay Area-to-Merced corridor. These variances and their underlying reasons are described below.

A. CALTRAIN SHARED USE OPTIONS

The Caltrain Shared Use options described in this report assumes the shared use of Caltrain commuter rail tracks by high-speed trains. These options would apply only for the steel-wheel-on-rail high-speed train technologies. To allow for potential incremental implementation of a high-speed train system, two Caltrain Shared Use options are evaluated:

A Basic Service Option, which would include grade separation of road crossings and fencing of the entire at-grade portion of the Caltrain corridor; however, four track-stations are not assumed at all local stations for this Option. Some local stations would be three-track and some two.

A Four-Track Station Option that would be consistent with the established criteria, allowing for high-speed trains to pass through or bypass local Caltrain stations on separate tracks.

FRA requlations currently prohibit operation of high-speed trains on tracks also used by freight trains, unless such trains can meet specific FRA criteria regarding "crash worthiness." Currently, the high-speed train equipment in use in Europe and Japan does not meet the FRA criteria. This report assumes that high-speed trains will be able to share tracks that would also be used both by Caltrain commuter rail and freight trains, i.e., that the issues regarding shared use track by freight and high-speed trains will be overcome. Possible resolution of this issue could occur via: (1) the temporal separation of high-speed and freight trains, (2) the removal of the freight trains from the lines (with commencerate provisions for freight access to the business served), (3) changes to high-speed train equipment to make it "crash worthy," and/or (4) revision to the FRA regulations.

An additional issue that will need to be addressed with shared use operation concerns clearances to platforms. Caltrain stations have low (eight inches above top of rail maximum) platforms. This is due to California Public Utiltities Commission (CPUC) regulations regarding horizontal clearances for conventional railroads. Current Caltrain passenger cars have steps that allow passengers to ascend from the platforms to the car floors. Special lifts are provided at stations for wheelchair accessibility. If high-speed trains were to share Caltrain platforms under current CPUC regulations, then the rolling stock will need to be equipped with stairs or steps. Other solutions to allow boarding at floor level are possible, but CPUC clearance regulations will need to be addressed.

B. TRANSBAY TERMINAL STATION IN SAN FRANCISCO

Two high-speed tracks with one center platform are assumed for the Transbay Terminal Station Option in San Francisco. This assumption is consistent with current plans for the Tranbay Terminal and environmental review currently being carried out by the Peninsula Commute Joint Power Board and the City and County of San Francisco. The number of tracks and platforms at this location are constrained by the size of the Transbay Terminal site and the need for both high-speed train and Caltrain tracks and platforms within the proposed new terminal. Additionally, the assumed High-speed train platform lengths for the Transbay Terminal Station would be 850 feet. This is again due to site size constraints at the new terminal.

2.2 EVALUATION METHODOLOGY

As listed in Table 2.2-1, a number of key evaluation objectives and criteria were developed based on previous studies with enhancements that reflect the Authority's high-speed train performance goals and criteria described in Task 1.5.2. These objectives and criteria have been applied in the screening of high-speed train alignment and station options developed as part of this process. Each of the evaluation criteria is discussed in Chapter 4.0, Alignment and Station Evaluation.

Table 2.2-1
High-Speed Train Alignment/Station Evaluation Objectives and Criteria

OBJECTIVE	CRITERIA
MAXIMIZE RIDERSHIP/REVENUE POTENTIAL	• TRAVEL TIME • LENGTH • POPULATION/EMPLOYMENT CATCHMENT
MAXIMIZE CONNECTIVITY AND ACCESSIBILITY	• INTERMODAL CONNECTIONS
MINIMIZE OPERATING AND CAPITAL COSTS	• LENGTH • OPERATIONAL ISSUES • CONSTRUCTION ISSUES • CAPITAL COST • RIGHT-OF-WAY ISSUES/COST
MAXIMIZE COMPATIBILITY WITH EXISTING AND PLANNED DEVELOPMENT	• LAND USE COMPATIBILITY AND CONFLICTS • VISUAL QUALITY IMPACTS
MINIMIZE IMPACTS TO NATURAL RESOURCES	• WATER RESOURCES • FLOODPLAIN IMPACTS • THREATENED & ENDANGERED SPECIES IMPACTS
MINIMIZE IMPACTS TO SOCIAL AND ECONOMIC RESOURCES	• ENVIRONMENTAL JUSTICE IMPACTS (DEMOGRAPHICS) • FARMLAND IMPACTS
MINIMIZE IMPACTS TO CULTURAL RESOURCES	• CULTURAL RESOURCES IMPACTS • PARKS & RECREATION/WILDLIFE REFUGE IMPACTS
MAXIMIZE AVOIDANCE OF AREAS WITH GEOLOGIC AND SOILS CONSTRAINTS	• SOILS/SLOPE CONSTRAINTS • SEISMIC CONSTRAINTS
MAXIMIZE AVOIDANCE OF AREAS WITH POTENTIAL HAZARDOUS MATERIALS	• HAZARDOUS MATERIALS/WASTE CONSTRAINTS

The engineering and environmental methodologies and assumptions used in evaluating the high-speed train alignment and station options are described in detail in the Authority's report prepared for Task 1.5.2.

2.2.1 Engineering Evaluation Criteria

The engineering evaluation criteria focus on cost and travel time as primary indicators of engineering viability and ridership potential. Items such as capital costs and travel times have been quantified for each of the alignment and station options considered. Other engineering criteria such as operational, construction, and ROW issues are presented qualitatively.

The evaluation criteria presented are consistent with the criteria applied in the previous corridor evaluation study and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

A. BAY AREA-TO-MERCED CORRIDOR ENGINEERING METHODOLOGY VARIANCES

The Bay Area-to-Merced corridor engineering screening methodology varied from the statewide approach in the following areas:

- ROW cost for railroad property was based on recent purchases in the Bay area and for other similar locations where the UPRR has been willing to sell their ROW.
- The cost for single track aerial structure was assumed to be 60 percent of the standard structure.
- The size of the tunnel bore in the Oakland terminal area was substantially reduced due to anticipated lower speeds and the restrained available ROW. No reduction in cost was made for this reduced tunnel size. Tunnel costs will be refined once detailed geotechnical data are available.

2.2.2 Environmental Evaluation Criteria

The objectives related to the environment and the criteria used for evaluation are consistent with NEPA and CEQA. The environmental constraints and impacts criteria focus on environmental issues that can affect the location or selection of alignments and stations.

To identify potential impacts for the alignments and station locations, a number of readily available resource agency-approved Geographic Information System (GIS)-compatible digital data sources were used along with published information from federal, state, regional, and local planning documents and reports. For evaluation of alignments and stations, ROW widths dictated by engineering requirements were utilized to identify the amount of area within each segment containing certain characteristics. Some environmental issues required using various buffer widths that extended beyond the conceptual ROW for the segments. Where noted, field reconnaissance was required to view on-the-ground conditions and to provide relative values of certain resources.

A. BAY AREA-TO-MERCED CORRIDOR ENVIRONMENTAL METHODOLOGY VARIANCES

For the evaluation of environmental and related alignment and station characteristics, the Bay Area-to-Merced corridor analysis applied the following variations to the statewide approaches.

- The catchment area for employees and population in the Year 2020 was assumed to be equivalent to an airport catchment area rather than a 10-mile radius approach suggested in the statewide evaluation criteria. Based on Bay Area experience, it was noted that people will drive or travel from longer distiances (e.g., from Santa Rosa, Fairfield, Santa Cruz, etc.) to catch an inter-city flight, and the same assumption has be applied for the inter-city high-speed train system.

- Information regarding hazardous materials was not collected. The alignments for the Bay Area-to-Merced corridor are mainly on railroad or highway rights-of-way, and it was assumed that some level of hazardous materials may be present for such corridors, particularly along rail rights-of-way. It was therefore assumed that hazardous material sites would not be a major distinguising factor for this screeing analysis.

- An affirmative search was not performed for archeological nor historic architecture sites along the alignments. When known, however, historic sites were identifed.

- Soils/geology/seismic information was not evaluated for station sites. It was assumed that high-speed train alignments and stations designs will be based on local soils and geology information and to withstand maximum credible earthquakes.

Section 2.0 of the Sacramento to Bakersfield Alignment / Station Screening Evaluation Methodology

2.0 PARAMETERS/ASSUMPTIONS AND EVALUATION METHODOLOGY

Unless otherwise noted, the objectives, parameters, criteria, and methodologies described in this report are consistent with those applied in previous California high-speed train studies and documented in the *California High-Speed Train Program EIR/EIS*, *Task 1.5.2 – High-Speed Train Alignment/Station Screening Evaluation Methodology*.[8]

2.1 PARAMETERS/ASSUMPTIONS

High-speed train alignment and station options were developed through consistent application of system, engineering, and operating parameters as described in Task 1.5.2. The parameters and assumptions applied are consistent with those applied in previous planning and engineering studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed rail systems, and recommendations of VHS and maglev manufacturers.

2.1.1 Statewide Parameters/Assumptions

The design, cost, and performance parameters used in developing the alignment and station options are based on two technology groups (classified by speed) (Figure 2.1.1). The Very High Speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 km/h) utilizing steel-wheel-on-steel-rail technology. Requirements for a VHS system include a dedicated, fully grade-separated right-of-way with overhead catenary for electric propulsion. It is possible to integrate a VHS system into existing conventional rail lines in congested urban areas given resolution of certain equipment and operating compatibility issues. The magnetic levitation (maglev) group utilizes magnetic forces to lift and propel the train along a guideway and is designed for maximum operating speeds above that of VHS technology. A maglev system requires a dedicated guideway and may share right-of-way but not track with conventional train systems.

Figure 2.1.1
VHS and Maglev Technology

VHS Train (Germany ICE)

Maglev (Transrapid)

[8] Parsons Brinckerhoff. *California High-Speed Train Program EIR/EIS, Task 1.5.2 – High-Speed Train Alignments/Stations Screening Evaluation Methodology*. Prepared for California High-Speed Rail Authority, May 2001.

High-speed train system engineering design parameters used in developing the alignments were documented in Task 1.5.2 and include speeds, geometry, and clearances for both steel-wheel-on-steel-rail (VHS) and maglev high-speed train technologies. The parameters and criteria, summarized in Table 2.1-1, are consistent with previous California high-speed train studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

Table 2.1-1
Summary of Engineering Design Parameters

Parameter	Very High-Speed	Maglev
Double Track	Full	Full
Power Source	Electric	Electric
Grade Separations	Full	Full
Potential for Shared Use	Yes	No
Corridor Width ❑ **Desirable** ❑ **Minimum**	 100 ft (30.4 m) 50 ft (15.2 m)	 100 ft (30.4 m) 50 ft (15.2 m)
Top Speed	220 mph (350 km/h)	240 mph[(1)] (385 km/h)
Average Speed	125-155 mph (200-250 km/h)	145-175 mph (230-280 km/h)
Acceleration	0.4-1.3 mph/s[3] (0.6-2.1 km/h/s[4])	1.1-1.9 mph/s (1.8-3.2 km/h/s)
Deceleration	1.2 mph/s (1.9 km/h/s)	1.8 mph/s (2.9 km/h/s)
Minimum Horizontal Radius	500-650 ft (150-200 m)	1,150 ft (350 m) (2)
Minimum Horizontal Radius (at top speed)	15,600 ft @ 220 mph (4,750 m @ 350 km/h)	11,500 ft @ 240 mph (3,500 m @ 385 km/h)
Superelevation ❑ **Actual (Ea)** ❑ **Unbalanced (Eu)**	 7 in (180 mm) 5 in (125 mm)	 16° 5°
Grades ❑ **Desirable Maximum** ❑ **Absolute Maximum**	 3.5% 5.0%	 NA 10.0%
Minimum Vertical Radius Crest Curve (at top speed)	157,500 ft @ 220 mph (48,000 m @ 350 km/h)	205,700 ft @ 240 mph (62,700 m @ 385 km/h)
Minimum Vertical Radius Sag Curve (at top speed)	105,000 ft @ 220 mph (32,000 m @ 350 km/h)	137,100 ft @ 240 mph (41,800 m @ 385 km/h)
Horizontal Clearance (centerline of track to face of fixed object)	10 ft 4 in @ 220 mph (3.1 m @ 350 km/h)	9 ft 5 in @ 240 mph (2.8 m @ 385 km/h)
Vertical Clearance (top of rail to face of fixed object)	21 ft (6.4 m)	12 ft 2 in (3.7 m)
Track Centerline Spacing	15 ft 8 in @ 220 mph (4.7 m @ 350 km/h)	15 ft 9 in @ 240 mph (4.8 m @ 385 km/h)
Minimum Right-of-Way Requirements At-Grade/Cut-and-Fill/Retained Fill Aerial Structure Tunnel (Double Track) Tunnel (Twin Single Track) Trench/Box Section	 50 ft (15.2 m) 50 ft (15.2 m) 67 ft (20.4 m) 120 ft (36.6 m) 70 ft (21.3 m)	 47 ft (14.3 m) 49 ft (15 m) 67 ft (20.4 m) 120 ft (36.6 m) 73 ft (22.2 m)
Minimum Station Platform Length	1,300 ft (400 m)	1,300 ft (400 m)
Minimum Station Platform Width	30 ft (9 m)	30 ft (9 m)
Notes: 1- Top Speed Defined in Federal Maglev Deployment Plan 2- Transrapid USA, 1998. 3- mph/s – miles per hour-second 4- km/h/s – kilometers per hour-second		

Based on the minimum requirements listed in Table 2.1-1, three general right-of-way parameters were utilized for the screening evaluation: (1) a minimum right-of-way corridor of 50 feet (15.2 meters) was assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor was assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes and tunnels.

The overall operations strategy and conceptual service parameters that were assumed for high-speed train service in California are documented in Task 1.5.2. Specific scheduling and operations modeling analysis is currently underway and will be used in future detailed engineering and environmental analyses in the next phase of this study.

2.1.2 Sacramento to Bakersfield Parameter/Assumption Variances

The regional analysis for the Central Valley routes of the High-Speed Train system does not deviate from statewide parameters or assumptions in engineering or environmental categories.

Since the Central Valley regional routes cover about 270 miles of line, its alignments bear a strong responsibility for achieving the desired statewide travel time objectives. Thus it is imperative that the highest possible through train running speeds be maintained throughout the region. To meet this objective, alignments have been identified in each city-to-city sector that allow for full-speed running from one end of the region to the other. Some of these full-speed through alignments will allow for the use of the standard configuration for intermediate stations. Other through line segments, which are called express loops, do not allow for any stations along their length and thus would only be used by non-stopping trains at full speed. Corresponding line segments, however, called stopping track alignments, provide access to station sites off the full-speed routes. These line segments are engineered to the highest speed possible, but take account of the fact that all trains on them will be stopping at the station. Therefore, curvature and other engineering characteristics may be modified to reduce costs and impacts at the station approaches, as long as resulting speed constraints remain within the envelope of decelerating and accelerating train performance.

While the geographic constraints of the Central Valley region seem minimal compared to the mountainous terrain and densely urban conditions in other regions, other environmental and socio-economic constraints characterize the region, as emphasized by residents and regional leaders throughout the study process. Three major categories of impacts have been identified for the region:

- Agricultural lands. The Central Valley contains agricultural resources that contribute massively to California's economy and the food supply of the state and the nation. Preservation of prime agricultural lands or the minimizing of impacts of the High-Speed Train system to such lands becomes a significant category in the evaluation process.

- Sensitive resource environments. Both new and existing alignments must be evaluated for impacts to sensitive habitats of threatened and endangered species and impacts to non-agricultural natural land uses.

- Growth. The Central Valley is forecast to be a major area of growth in population and economic activity in the coming decades. The High-Speed Train system will have strong consequences for the spatial development of station cities along its route. Evaluation of land uses, both existing and new, has been a strong concern of all Central Valley officials and stakeholders in the environmental process. This is particularly evident in the discussion of central city versus outlying station sites.

2.2 EVALUATION METHODOLOGY

As listed in Table 2.2-1, a number of key evaluation objectives and criteria were developed based on previous studies with enhancements that reflect the Authority's high-speed train performance goals and criteria described in Task 1.5.2. These objectives and criteria have been applied in the screening of high-speed train alignment and station options developed as part of this process. Each of the evaluation criteria is discussed in Chapter 4.0, Alignment and Station Evaluation.

Table 2.2-1
High-Speed Rail Alignment/Station Evaluation Objectives and Criteria

Objective	Criteria
Maximize Ridership/Revenue Potential	▪ Travel Time ▪ Length ▪ Population/Employment Catchment
Maximize Connectivity and Accessibility	▪ Intermodal Connections
Minimize Operating and Capital Costs	▪ Length ▪ Operational Issues ▪ Construction Issues ▪ Capital Cost ▪ Right-of-Way Issues/Cost
Maximize Compatibility with Existing and Planned Development	▪ Land Use Compatibility and Conflicts ▪ Visual Quality Impacts
Minimize Impacts to Natural Resources	▪ Water Resources ▪ Floodplain Impacts ▪ Threatened & Endangered Species Impacts
Minimize Impacts to Social and Economic Resources	▪ Environmental Justice Impacts (Demographics) ▪ Farmland Impacts
Minimize Impacts to Cultural Resources	▪ Cultural Resources Impacts ▪ Parks & Recreation/Wildlife Refuge Impacts
Maximize Avoidance of Areas with Geologic and Soils Constraints	▪ Soils/Slope Constraints ▪ Seismic Constraints
Maximize Avoidance of Areas with Potential Hazardous Materials	▪ Hazardous Materials/Waste Constraints

The engineering and environmental methodologies and assumptions used in evaluating the high-speed train alignment and station options are described in detail in Task 1.5.2.

2.2.1 ENGINEERING EVALUATION CRITERIA

The engineering evaluation criteria focus on cost and travel time as primary indicators of engineering viability and ridership potential. Items such as capital costs and travel times have been quantified for each of the alignment and station options considered. Other engineering criteria such as operational, construction, and right of way issues are presented qualitatively.

The evaluation criteria presented are consistent with the criteria applied in the previous corridor evaluation study and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

A. SACRAMENTO TO BAKERSFIELD ENGINEERING METHODOLOGY VARIANCES

The relative lack of geographic constraints in the Sacramento to Bakersfield region raises no compelling differences in the performance characteristics of steel-wheel-on-steel-rail vehicles versus magnetic levitation vehicles. Thus no differential alignments have been proposed for maglev technology. The two technologies will be distinguished in the region only by the categories of travel time and costs.

2.2.2 Environmental Evaluation Criteria

The objectives related to the environment and the criteria used for evaluation are consistent with NEPA and CEQA. The environmental constraints and impacts criteria focus on environmental issues that can affect the location or selection of alignments and stations.

To identify potential impacts for the alignments and station locations, a number of readily available resource agency-approved Geographic Information System (GIS)-compatible digital data sources were used along with published information from federal, state, regional, and local planning documents and reports. For evaluation of alignments and stations, right-of-way widths dictated by engineering requirements were utilized to identify the amount of area within each segment containing certain characteristics. Some environmental issues required using various buffer widths that extended beyond the conceptual right-of-way for the segments. Where noted, field reconnaissance was required to view on-the-ground conditions and to provide relative values of certain resources.

B. SACRAMENTO TO BAKERSFIELD ENVIRONMENTAL METHODOLOGY VARIANCES

This discussion highlights the information used to evaluate the alternative alignments and station locations. For some environmental factors, the amount of information collected and considered is more extensive than recommended in the Task 1.5.2 Screening Methodology Report; in other cases, the information desired for the screening methodology was not available and surrogate data were used instead.

Environmental Factor	Environmental Measures	Variance from Task 1.5.2 Report	Rationale
Land Use – Potential Land Acquisition and Displacement	▪ Acres of existing land use within ROW; approximately 30 different land use categories	Land acquisition and displacement not specifically addressed by screening report, which focused more on land use compatibility; i.e., effects on adjacent land uses.	Land use within ROW will help identify loss of jobs, housing, social institutions and public facilities. Also, desirable to develop ROW cost estimates.
Land Use – Land Use Compatibility	▪ Acres of existing land use adjacent to HSR corridor	Lands within 200 feet of the alignment centerline were considered sufficient to identify potential land use compatibility issues. Land uses were aggregated into approximately 12 different categories to assess compatibility. The percentage of each type of land use was calculated to get a sense of the composition of land uses in the segment or station area.	Most favorable adjacent land uses would be Open Space (disturbed/ developed), Commercial and Office; least favorable adjacent land uses would be Residential (ranchettes, single family), Institutional (school, hospital, church, library). Moderately favorable adjacent land uses would be Industrial, Institutional (military, government), Residential (multi-family), Recreation.

Environmental Factor	Environmental Measures	Variance from Task 1.5.2 Report	Rationale
Land Use – Consistency with General Plan and Public Policies	▪ Acres of General Plan land use adjacent to HSR corridor	Lands within 200 feet of the alignment centerline and 1/2-mile station area radii were considered sufficient to identify support or impedance of local land use policies. Land uses were aggregated into approximately 12 different categories to assess compatibility. The percentage of each type of land use was calculated to get a sense of the composition of land uses in the segment or station area. Information regarding local Redevelopment Plan areas was collected to further inform this assessment.	Same as above
Visual Quality	▪ Acres of existing land use adjacent to HSR corridor	Lands 1/2-mile station area radii were considered sufficient to capture the first row of viewers. Visual characteristics along the alignments were not collected.	Visual impacts of alternative alignments between station areas were not considered to be a significant factor in distinguishing among the alignments.
Water Resources - Streams	▪ Number of stream crossings within the ROW ▪ Natural v. Improved ▪ Left Bank v. Right Bank	Additional data evaluated regarding the type of stream	Crossing/disturbance of natural stream crossings would presumably result in greater environmental impacts.
Water Resources - Floodplains	▪ Incidences of crossings within the ROW ▪ Length of crossing ▪ Acres of encroachment	Additional data evaluated regarding the incidence and length of floodplain crossings	Desirable to know how many flood hazard areas are affected and length of disturbance for cost and better understanding of amount of floodplain capacity displaced. For example, two different segments affected about 3 acres of floodplain, but one segment had nine floodplain crossings and total length of encroachment of 330m; whereas, the second segment had one floodplain crossing over 408 meters.
Water Resources - Wetlands	▪ Incidences of crossings ▪ Length of crossing ▪ Acres of encroachment within ROW ▪ Acres of encroachment within 400 feet	Screening report calls for identifying acres of wetlands within and adjacent to the HSR corridor. "Adjacent areas" addressed by 400-foot buffer.	
Biological Resources - Threatened and Endangered Species	▪ Count of species within ROW ▪ Count of species within 400 feet	Screening report calls for identifying affected species within and adjacent to HSR corridor. "Adjacent areas" addressed by 400-foot buffer.	CNDDB contains overlapping polygons which does not allow GIS determination of acreage of endangered species habitat within or adjacent to corridor. Sensitive habitat impacts identified using GAP data (see row below).

Environmental Factor	Environmental Measures	Variance from Task 1.5.2 Report	Rationale
Biological Resources - Sensitive Habitat	▪ Acres of encroachment within ROW ▪ Acres of encroachment within 400 feet ▪ Acres by each habitat type reported in the GAP database	Use of GAP habitat data as a surrogate for threatened and endangered species.	CNDDB does not lend itself to GIS queries. GAP data, listing some 30 habitat types, were linked to the State system of rating habitats for biological sensitivity. State ranks 1.1, 1.2, 2.1, 2.2, 3.1, and 3.2 indicate the presence of threatened and endangered species.
Environmental Justice	▪ Ethnic minority population within Census block groups that have >50% minority ▪ Low income households within Census block groups	All block groups that occurred within 1400-foot buffer were included in analysis; even if only a small portion of the block group was inside the buffer. Low-income populations are defined by Census definition of low-income; not sure how this relates to $12.6k figure in the screening report.	
Farmlands	▪ Acres of Prime, Unique, and Statewide Importance within the ROW	None	
Cultural Resources	▪ Incidences of NRHP properties within ROW ▪ Incidences of NHRP properties within 400 feet	NRHP data file was consulted. Properties "adjacent" to the HSR were also considered.	Other data sources such as CHRIS and local inventories were not consulted because they did not exist electronically. Resources were also identified within 400 feet of alignment to capture indirect effects that might result from change in visual or audible setting or in access.
Parks and Recreation/Wildlife Refuge	▪ Incidences of park and recreation properties within ROW and within 400 feet ▪ Acres of park and recreation properties within ROW and within 400 feet	Properties "adjacent" to the HSR were also considered.	Resources were also identified within 400 feet of alignment to capture indirect effects that might result from change in visual or audible setting or in access.
Soils/Slope Constraints	*waiting for info from Kleinfelder*		
Seismic Constraints	*waiting for info from Kleinfelder*		
Hazardous Materials/Waste Constraints	*waiting for info from Kleinfelder*		

Section 2.0 of the Bakersfield to Los Angeles Alignment / Station Screening Evaluation Methodology

2.0 PARAMETERS/ASSUMPTIONS AND EVALUATION METHODOLOGY

Unless otherwise noted, the objectives, parameters, criteria, and methodologies described in this report are consistent with those applied in previous California high-speed train studies and documented in the *California High-Speed Train Program EIR/EIS*, *Task 1.5.2 – High-Speed Train Alignment/Station Screening Evaluation Methodology*.[7]

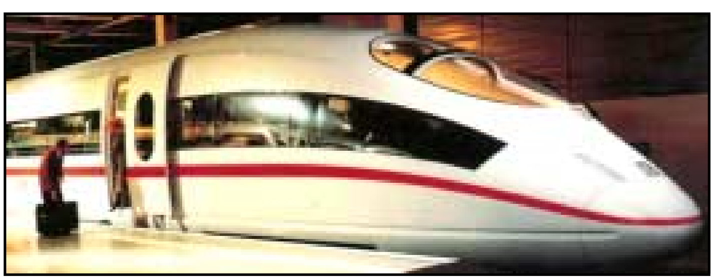
2.1 PARAMETERS/ASSUMPTIONS

High-speed train alignment and station options were developed through consistent application of system, engineering, and operating parameters as described in Task 1.5.2. The parameters and assumptions applied are consistent with those applied in previous planning and engineering studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed rail systems, and recommendations of VHS and maglev manufacturers.

2.1.1 Statewide Parameters/Assumptions

The design, cost, and performance parameters used in developing the alignment and station options are based on two technology groups (classified by speed) (Figure 2.1.1). The Very High-Speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 km/h) utilizing steel-wheel-on-steel-rail technology. Requirements for a VHS system include a dedicated, fully grade-separated right-of-way with overhead catenary for electric propulsion. However, it is possible to integrate a VHS system into existing conventional rail lines in congested urban areas given resolution of certain equipment and operating compatibility issues. The magnetic levitation (maglev) group utilizes magnetic forces to lift and propel the train along a guideway and is designed for maximum operating speeds above that of VHS technology. A maglev system requires a dedicated guideway and may share right-of-way, but not track, with conventional train systems.

Figure 2.1-1
VHS and Maglev Technology



VHS Train (Germany ICE)

Maglev (Transrapid)

[7] Parsons Brinckerhoff. *California High-Speed Train Program EIR/EIS, Task 1.5.2 – High-Speed Train Alignments/Stations Screening Evaluation Methodology*. Prepared for California High-Speed Rail Authority, May 2001.

High-speed train system engineering design parameters used in developing the alignments were documented in Task 1.5.2 and include speeds, geometry, and clearances for both steel-wheel-on-steel-rail (VHS) and maglev high-speed train technologies. The parameters and criteria, summarized in Table 2.1-1, are consistent with previous California high-speed train studies and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

Table 2.1-1
Summary of Engineering Design Parameters

Parameter	Very High-Speed	Maglev
Double Track	Full	Full
Power Source	Electric	Electric
Grade Separations	Full	Full
Potential for Shared Use	Yes	No
Corridor Width ❑ **Desirable** ❑ **Minimum**	 100 ft (30.4 m) 50 ft (15.2 m)	 100 ft (30.4 m) 50 ft (15.2 m)
Top Speed	220 mph (350 km/h)	240 mph(1) (385 km/h)
Average Speed	125-155 mph (200-250 km/h)	145-175 mph (230-280 km/h)
Acceleration	0.4-1.3 mph/s(3) (0.6-2.1 km/h/s(4))	1.1-1.9 mph/s (1.8-3.2 km/h/s)
Deceleration	1.2 mph/s (1.9 km/h/s)	1.8 mph/s (2.9 km/h/s)
Minimum Horizontal Radius	500-650 ft (150-200 m)	1,150 ft (350 m) (2)
Minimum Horizontal Radius (at top speed)	15,600 ft @ 220 mph (4,750 m @ 350 km/h)	11,500 ft @ 240 mph (3,500 m @ 385 km/h)
Superelevation ❑ **Actual (Ea)** ❑ **Unbalanced (Eu)**	 7 in (180 mm) 5 in (125 mm)	 16° 5°
Grades ❑ **Desirable Maximum** ❑ **Absolute Maximum**	 3.5% 5.0%	 NA 10.0%
Minimum Vertical Radius Crest Curve (at top speed)	157,500 ft @ 220 mph (48,000 m @ 350 km/h)	205,700 ft @ 240 mph (62,700 m @ 385 km/h)
Minimum Vertical Radius Sag Curve (at top speed)	105,000 ft @ 220 mph (32,000 m @ 350 km/h)	137,100 ft @ 240 mph (41,800 m @ 385 km/h)
Horizontal Clearance (centerline of track to face of fixed object)	10 ft 4 in @ 220 mph (3.1 m @ 350 km/h)	9 ft 5 in @ 240 mph (2.8 m @ 385 km/h)
Vertical Clearance (top of rail to face of fixed object)	21 ft (6.4 m)	12 ft 2 in (3.7 m)
Track Centerline Spacing	15 ft 8 in @ 220 mph (4.7 m @ 350 km/h)	15 ft 9 in @ 240 mph (4.8 m @ 385 km/h)
Minimum Right-of-Way Requirements At-Grade/Cut-and-Fill/Retained Fill Aerial Structure Tunnel (Double Track) Tunnel (Twin Single Track) Trench/Box Section	 50 ft (15.2 m) 50 ft (15.2 m) 67 ft (20.4 m) 120 ft (36.6 m) 70 ft (21.3 m)	 47 ft (14.3 m) 49 ft (15 m) 67 ft (20.4 m) 120 ft (36.6 m) 73 ft (22.2 m)
Minimum Station Platform Length	1,300 ft (400 m)	1,300 ft (400 m)
Minimum Station Platform Width	30 ft (9 m)	30 ft (9 m)

Notes: 1- Top Speed Defined in Federal Maglev Deployment Plan
2- Transrapid USA, 1998.
3- mph/s – miles per hour-second
4- km/h/s – kilometers per hour-second

Based on the minimum requirements listed in Table 2.1-1, three general right-of-way parameters were utilized for the screening evaluation: (1) a minimum right-of-way corridor of 50 feet (15.2 meters) was assumed in congested corridors; (2) a 100-foot (30.4-meter) corridor was assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes and tunnels.

The overall operations strategy and conceptual service parameters that were assumed for high-speed train service in California are documented in Task 1.5.2. Specific scheduling and operations modeling analysis is currently underway and will be used in future detailed engineering and environmental analyses in the next phase of this study.

2.1.2 Bakersfield-to-Los Angeles Parameter/Assumption Variances

The engineering assumptions used to evaluate the Bakersfield-to-Los Angeles corridor generally mirror those in Task 1.5.2. In some cases, however, the high-speed train system engineering design parameters developed for the statewide system were modified somewhat to better match local conditions encountered within the region, respond to recent development activity, improve system operations, avoid environmental impacts and concomitant mitigation requirements, reduce energy demand and lower maintenance costs.

A. CORRIDOR WIDTH

A corridor width of 50 feet was applied to the dense urban segment between Sylmar and Los Angeles Union Station. This minimum width reflects the intensive land use constraints extant in this corridor. A full 100-foot wide corridor was assumed for the segment between Bakersfield and Sylmar due to its less intensive suburban and rural character, and sections of mountainous terrain. No allowance was made for slope easements.

B. GRADES

Earlier studies of the Bakersfield-to-Los Angeles corridor aimed at minimizing the overall length of tunnels along their respective alignment alternatives. A series of vertical profile alternatives were developed using various gradients – from conventional (1.5 percent maximum) to aggressive (5 percent maximum for VHS) – with the dual goals of reducing tunnels through the Tehachapis and avoiding tunnel crossings of the two major faults (San Andreas and Garlock). A 3.5 percent gradient profile was used in developing alignments presented in the California High-Speed Rail Authority Final Business Plan (June 2000). Use of the 3.5 percent grade allowed tunneling along the Business Plan's I-5 and Antelope Valley alignments to be limited to a total of 28 miles (18 km) and 11 miles (7 km), respectively.

Grades of up to 3.5 percent have been employed in European high-speed train systems. The use of higher gradients; however, has largely been avoided due to loss in speed or increase in power consumption. The CTRL under construction in England, with a design speed of 280 kph, employs 2.5 percent grades without limit and limited 3 percent grades (600 meter maximum length). TGV's Paris to Marseille route, which opened most recently, features operating speeds of up to 330 kph and 6 km-long grades at up 3.5 percent. From Paris to Lyon along LGV Paris Sud-Est, which includes a vertical climb of approximately 450 meters, tunneling is completely avoided by constructing many short stretches of steeper gradient.

Due to the broad-reaching implications of gradient criteria within this region, significant consideration was given to the application of the desirable maximum grade along the alignment. Use of the 3.5 percent grade criterion set forth in the Business Plan results in a series of short tunnels and an overall reduction in tunneling length. The 2.5 percent-maximum grade alignments that were also considered in the current study would substantially increase total tunnel length, but would offer improved operating characteristics and lessened environmental impacts. While tunnel construction includes inherent construction issues, some additional challenges would be presented by the construction of a series of short tunnels, rather than fewer, longer tunnels. These issues are described in more detail below.

The most important factor in the approach to grades made by earlier studies was to avoid tunnels at fault crossings. The use of at least a 3.5 percent grade allows alignments along I-5 and SR-58 to be aboveground at crossings of the San Andreas Fault and the Garlock Fault, respectively. The southerly tunnel portal on the 3.5 percent I-5 alignment; however, is very close to the San Andreas fault zone, that significant seismic movement at the portal itself could be expected. Where a flatter grade is applied, seismic chambers would be required at fault crossings to allow train service to be restored after an earthquake event.

Evacuation routes must also be considered in the construction of tunnels. Longer, deeper tunnels that do not provide opportunities for escape along their length would require the construction of parallel evacuation routes. These parallel tunnels add significant cost to the alignment options through the Tehachapi Mountains.

Train Performance

Long, steep gradients require additional power while reducing train speeds and operational capabilities. The German Peer Review prepared by DE Consult (December 2000) shows that train performance is compromised on long, sustained gradients. For gradients of 3.5 percent, the newest technology trainset can be expected to lose 50 percent of its 220 mph (350 kph) top speed over a length of 19 miles (30 km). While speed reduction is significant, the impacts on travel times would be fairly limited in crossing the Tehachapis because sustained grades are generally no longer than 9 miles (15 km) – only one additional minute of travel time would be expected to traverse a steeper 3.5 percent alignment as compared to a 2.5 percent maximum grade alignment.

On the downhill, however, steep grades can tax braking systems. Braking of high-speed trains is accomplished by a combination of wheel, pneumatic, and dynamic braking systems. At speeds up to 220 mph (350 kph), significant energy is required to slow the train. Additionally, on steep downgrades, the train's high kinetic energy can overheat braking systems or, in worst cases, cause heat stress to the railhead Specific speed instructions are required prior to down grade to properly employ brakes and to prevent runaway trains.

In addition to speed consequences, operation over steeper grades presents power implications. Sustained 3.5 percent grades demand higher power and tractive effort. The peer review by DE Consult indicates that trainsets with distributed power would be required to climb this gradient, even with speed losses described above. Earlier reports prepared by DE Consult and Parsons Brinckerhoff (Travel Time and Energy Usage Analysis and Results, December 1994) do not present specific comparisons of 2.5 percent versus 3.5 percent grades, but show that energy consumption increases 10 percent to 40 percent for uphill operation on 3.5 percent grade as compared to the downhill operation along the same alignment.

Tunnel Portal Effects

Higher gradients, with shorter, but generally more, tunnels present operational issues related to tunnel portal effects. As high-speed vehicles enter tunnels, they create compression and expansion waves that run the length of the tunnel and back again at the speed of sound. These waves created by high-speed trains in smooth and long tunnels can cause pain to eardrums and can potentially shatter glass. Moreover, under unfavorable conditions, people living near-by tunnel portals could suffer from the noise and vibrations (phenomena designated as "sonic boom") caused by the transmission, in the surroundings of tunnels exits, of an impulsive spherical pressure wave. The later is called "micro-pressure wave"; it is created when the wavefront of the primary compression wave is reflected the first time it reaches the tunnel end. Such phenomena can result in less effective HST speeds-up or even, worse, in speed reductions. While no micro-pressure waves strong enough to result in a sonic boom have ever yet been recorded at tunnel exits in Europe in revenue service conditions, such an event is likely to happen soon as slab track technology starts to be applied to long tunnels across Europe.

A variety of methods have been employed to address pressure waves at tunnel portals. The intensity of acoustic waves can be minimized by applying speed restrictions, precluding the passing of trains within tunnels, modifying rolling stock, adopting an oversize tunnel cross-section, and/or incorporating pressure alleviation devices at portals and along tunnel lengths.

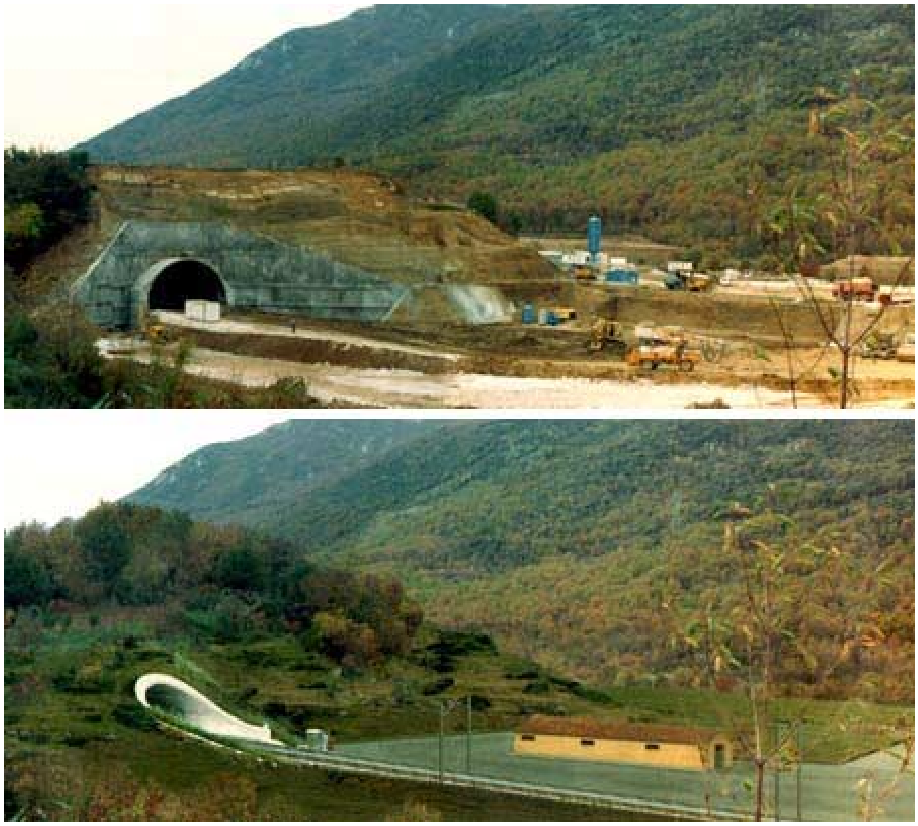
Proper portal design is critical to minimizing operational and comfort impacts at tunnel entrances. Flared shapes, elongated portals, and perforated entrance hoods serve to reduce aerodynamic effects. To diffuse air pressures, portals vary in length from 150 meters to 300 meters, dependent upon design.

Accommodations along tunnel length can be used to also improve aerodynamics. Porous dividing walls, cross-passages, and airshafts connected to the surface can help minimize pressure waves. The construction of a number of airshafts located at positions spread along the length of the tunnel can reduce pressure wave strengths; however, shaft sites require access for construction and future maintenance.

Construction Issues Related to Grade

Tunnel construction can be significantly reduced by increasing profile gradient. Under the 3.5 percent grade alignments, tunnels are generally shorter and shallower, reducing the construction risks inherent to tunneling.

Conversely, multiple short tunnels mean that there would be more tunnel portals. Access for construction and operations would be required at each tunnel portal. Each portal results in a large area of disturbance to allow for construction of lengthy portal walls designed to minimize tunnel blast effects. Through the Tehachapi Crossing, portal areas are generally in remote and sensitive locations, where the construction of portals and related infrastructure will have significant impacts.



Construction (top) and simulated completed tunnel portal (bottom) on Rome to Naples high-speed rail line in Italy.

Multiple short tunnels also mean a requirement for more tunnel boring machines (TBMs) and TBM and equipment staging areas. The TBM must be reset at each portal, increasing mobilization costs and offsetting the efficiency that is achieved in a continuous TBM drive. Power must be brought in to start and run each TBM, with the peak power requirement needed to start the bore. This requires construction of substations and power lines to the portal site. These requirements result in further environmental impacts.

Grade and tunnel features of the Tehachapi crossing also have constructibility implications. The construction of the Bakersfield-to-Los Angeles alignment would generate significant spoil, resulting from both cut and tunneling through the mountains. A 7.0-meter diameter (single track) tunnel would produce 38,500 cubic meters of spoil for every kilometer of tunneling. The most effective method of removing and disposing of excavated soils would likely be by rail; however, conventional rail equipment cannot climb sustained grades in excess of 2.5 percent. If spoil cannot be removed by rail, it must be trucked or conveyored from the tunnel portal to the eventual disposal site. This would require use of access roads, conveyor routes and establishment of spoil disposal sites in the vicinity of the tunnel portal.

Comparison of Grade Alternatives

Given these considerations, in addition to the 3.5 percent maximum grade, vertical alignments over the Tehachapis with grades limited to 2.5 percent were considered in the screening analysis. Cost comparison of the 2.5 percent versus 3.5 percent maximum grade profiles along the Bakersfield-to-Sylmar alignment segment that reduced-grade options would significantly increase projected capital cost – by approximately $500 Million for the I-5 Alignment option. This capital cost increase would be offset by the operating benefits of lesser gradients, including power consumption reduction of 10 percent to 20 percent, as well as lower anticipated maintenance costs.

Assuming that tunnel air blast effects are addressed so that train speeds need not be reduced at portals, grade is not a significant factor in travel time over the Tehachapis. Travel times from Bakersfield-to-Sylmar are only marginally improved (by approximately one minute depending upon alignment option) by use of flatter gradients. This time savings is likely to be increased by higher speeds that may be realized due to fewer tunnel portal effects.

2.2 EVALUATION METHODOLOGY

As listed in Table 2.2-1, a number of key evaluation objectives and criteria were developed based on previous studies with enhancements that reflect the Authority's high-speed train performance goals and criteria described in Task 1.5.2. These objectives and criteria have been applied in the screening of high-speed train alignment and station options developed as part of this process. Each of the evaluation criteria is discussed in Chapter 4.0, Alignment and Station Evaluation.

Table 2.2-1
High-Speed Rail Alignment/Station Evaluation Objectives and Criteria

Objective	Criteria
Maximize Ridership/Revenue Potential	▪ Travel Time ▪ Length ▪ Population/Employment Catchment
Maximize Connectivity and Accessibility	▪ Intermodal Connections
Minimize Operating and Capital Costs	▪ Length ▪ Operational Issues ▪ Construction Issues ▪ Capital Cost ▪ Right-of-Way Issues/Cost
Maximize Compatibility with Existing and Planned Development	▪ Land Use Compatibility and Conflicts ▪ Visual Quality Impacts
Minimize Impacts to Natural Resources	▪ Water Resources ▪ Floodplain Impacts ▪ Threatened & Endangered Species Impacts
Minimize Impacts to Social and Economic Resources	▪ Environmental Justice Impacts (Demographics) ▪ Farmland Impacts
Minimize Impacts to Cultural Resources	▪ Cultural Resources Impacts ▪ Parks & Recreation/Wildlife Refuge Impacts
Maximize Avoidance of Areas with Geologic and Soils Constraints	▪ Soils/Slope Constraints ▪ Seismic Constraints
Maximize Avoidance of Areas with Potential Hazardous Materials	▪ Hazardous Materials/Waste Constraints

The engineering and environmental methodologies and assumptions used in evaluating the high-speed train alignment and station options are described in detail in Task 1.5.2.

2.2.1 Engineering Evaluation Criteria

The engineering evaluation criteria focus on cost and travel time as primary indicators of engineering viability and ridership potential. Items such as capital costs and travel times have been quantified for each of the alignment and station options considered. Other engineering criteria such as operational, construction, and right of way issues are presented qualitatively.

The evaluation criteria presented are consistent with the criteria applied in the previous corridor evaluation study and are based on accepted engineering practice, the criteria and experiences of other railway and high-speed train systems, and recommendations of VHS and maglev manufacturers.

A. BAKERSFIELD-TO-LOS ANGELES ENGINEERING METHODOLOGY VARIANCES

Travel Time

Travel time was calculated as express travel time from the Bakersfield Golden State Station to Los Angeles Union Station. Travel time calculations considered alignment design speeds and reflected acceleration times and 6 percent schedule recover time, consistent with the statewide criteria. Travel time data from the Sacramento to Bakersfield corridor was provided for three representative links from the Bakersfield Golden State station site to the three connection points to the Bakersfield-to-Los Angeles region. These connection points are located along I-5, in the area of Comanche Point and along SR-58, each at the base of the Tehachapi Mountains in the Central Valley. For the purposes of analysis, it was assumed that southbound trains departing from Bakersfield will have achieved full operating speed by the connection points. Travel times reflect maximum operating speeds of 220 mph (350 kph), subject to speed reductions on sustained grades. Speed losses were assumed to be consistent with the analysis prepared by DE Consult, showing decreases in top train speeds for various ICE trainsets **(Figure 2.2-1)** along sustained 3.5 percent gradients. The characteristics of the DPT400 trainset, the Germans' most advanced VHS technology, were used in calculating speeds. For simplicity, speed losses were assumed to be linear for grades up to 12 miles (20 km). None of the alignments studied includes individual sustained grades longer than 12 miles (20 km).

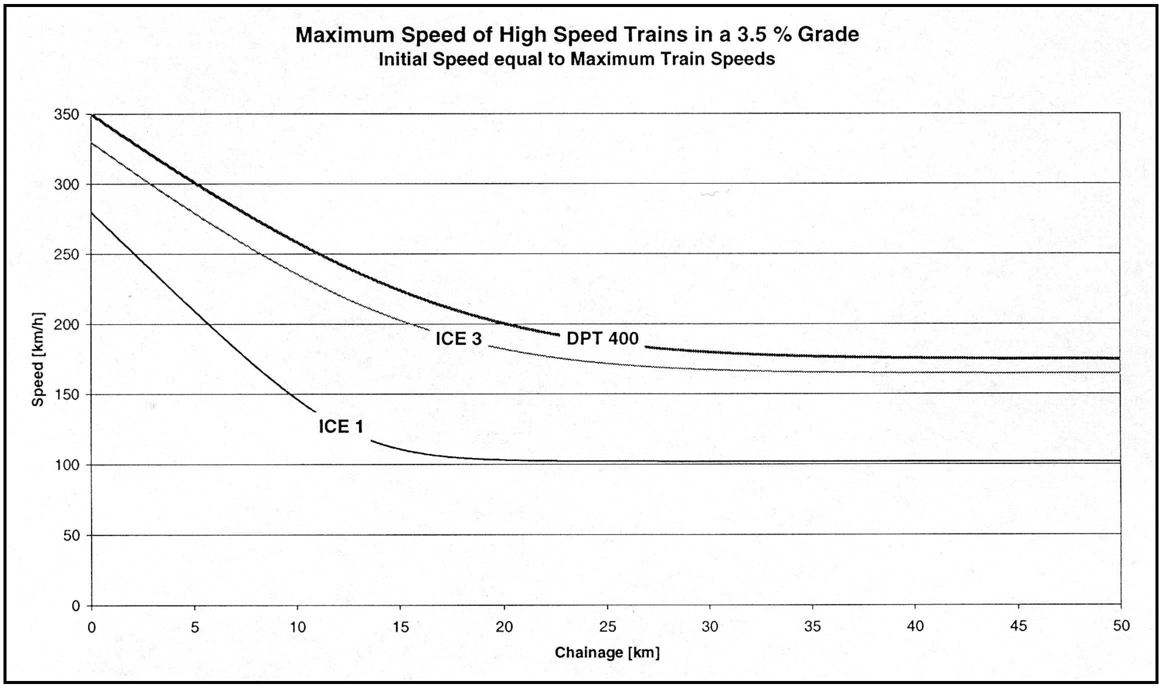


Figure 2.2-1 – Projected Speed Losses on Sustained 3.5 percent Gradient

For approaches into/out of LAUS, appropriate acceleration rates and times were considered, as set forth in the engineering criteria. Additionally, travel times considered the feasibility of achieving design speeds, given adjacent speed constraints. For example, where operating speeds were constrained at either end of a specific segment, travel times assume that trains would maintain a restricted speed through short unconstrained segments lying between constrained-speed areas, rather than quickly accelerating and decelerating.

Travel times were also calculated for the San Diego connection alternatives. Acceleration times and speeds were calculated, consistent with established engineering criteria and alignment constraints. This information was provided to the Los Angeles to San Diego teams for their use in evaluating alignment options within those corridors. Connection points to the San Diego alignments are as follows:

Option 1 & 1A	Soto Street
Option 2	Alameda Street
Option 3 & 3A	Soto Street
Option 4	Soto Street
Option 5	Soto Street

Length

While alignments were evaluated based on measured length of segments, length was also a factor in evaluating certain station site options. Alignments were compared and rated against one another based on overall length. Because alignment approaches to downtown Los Angeles are highly dependent upon the proposed location of Los Angeles Union Station (LAUS), additional alignment length required to accommodate a particular station site was considered in developing the length ratings for station options.

Population/Employment Catchment

The amount of population and/or employment within a defined area surrounding potential station options was used as a surrogate for ridership potential. This measurement is only applicable for comparing station locations that are a significant distance apart. For station locations that were closely spaced (less than five miles apart), the population/employment data was calculated for only one of the closely spaced station sites. A catchment area of 20 miles was used for stations 20 miles or more apart. A catchment area of 10 miles was used for stations closer than 20 miles apart.

This information should be used to consider the relative effectiveness of the stations in attracting passengers on a regional or system-wide basis, or when potential station sites for a given area are spaced far apart.

Connectivity and Accessibility

The varied means and modes of access to station locations was inventoried. This includes freeways and their proximity to the station site, availability of direct access from freeways or arterial streets, other rail or transit systems, express busways, local bus service, shuttle bus service, proximity to airports, and pedestrian and bicycle access. Stations were given higher scores for having a greater number of and more efficient access and transfer options.

Operational Issues

Operating implications of alternatives were evaluated based on the potential safety, reliability, and flexibility that could be offered by the alignment alternative or station site option. Alignment and station alternatives that presented the fewest potential constraints to train movements were rated highest. Alignment ratings with respect to operational issues reflect a composite of ratings for Grade, Curvature, Tunnel Length, and Tunnel Portals.

Operating Speeds
Alignments were compared with respect to their ability to achieve and maintain 220 mph (350 kph) operating speed. Alignments that cannot provide for top speeds throughout their length were ranked less favorably.

Grade
Steep grades, particularly in close proximity to station sites, were considered negative operational conditions. Sustained grades can degrade train performance and increase operating and maintenance costs. Grades of 1 percent or less were considered the most favorable. Where alignments achieve gradients of up to 3.5 percent, a least favorable rating was made.

Curvature
Horizontal curvature of high-speed alignments allows them to avoid various constraints, including existing development and topography, thereby minimizing capital costs and reducing impacts. Conversely, curvature acts to constrain operations and increase operating costs. The presence of curves will limit the location of turnouts and crossovers, since these must be located on tangent sections of track, which are important to providing access to stations and to

allow for train meets (passing of trains) between stations. The use of small-radius curvature may also increase maintenance costs along the alignment due to uneven rail wear. The light weight of high-speed rolling stock; however, may make large-radius curves preferable to long tangent track by forcing the train against the rails and preventing "seeking" motion, where the train wanders from side to side, which increases rail wear. The most favorable ratings with respect to curvature were given the alignments with very large radius curves or near-straight alignments, those with fewer curves in close proximity to stations, and with the fewest number of minimum radii (4750 m.) curves at top speed. Alignments that included significant curvature or require radii below the top speed received the least favorable rating.

Tunnel Length
Provisions and procedures must be made for evacuation from long, deep tunnels. Tunnels must also be equipped with ventilation and life safety systems. Therefore, alignments with longer tunnels, which present safety concerns, generated a lesser rating for this evaluation factor. Where intermediate access along tunnels longer than 8 miles (13 km) could not be attained, an adjacent evacuation was also assumed. This third bore, while increasing construction risk and capital cost, somewhat offset safety concerns of longer tunnels.

Tunnel Portals
In addition to the total length of tunnels, the number of tunnel portals was considered in evaluating alignment alternatives. Individual tunnel portals present operational challenges that were considered in alignment ratings. High-speed train tunnels require accommodation at portals to diffuse air pressures during train entrance and exit. Portal characteristics will have implications on train performance, passenger comfort, noise and vibration impacts, and capital costs.

Construction Issues

The generalized constructibility or ease of construction for the various alternatives was considered in the evaluation of alignments and stations. Factors considered included: site access, ability to use conventional construction methods, earthwork and structures.

Site Access
Ease of construction is influenced by the ability to access the alignment from existing public rights of way. Alignment reaches that are constrained by close development or are not accessible from existing roadways make construction more difficult, resulting in a lesser rating. Maintenance of traffic was considered a limitation of site access; adjacent vehicular traffic and adjacent railroad operations that would preclude unlimited construction access resulted in less favorable ratings for this factor.

Construction Methods
The ability to use conventional construction equipment was a significant factor considered in evaluating construction issues for the various alignment alternatives. The requirement for underground construction, where unforeseen conditions are likely to be encountered, resulted in less favorable ratings.

The construction of mountain tunnels is assumed to be accomplished with tunnel boring machines (TBMs). Once set in place, the typical TBM will produce approximately 1000 cubic meters of spoil per day. This can be severely and negatively impacted by the ripability of soils encountered. Additionally, TBM efficiency may be severely undermined where soil and rock conditions vary significantly along the tunnel length. As a result, lengthy tunneling and the presence of rock at deep excavations resulted in least favorable ratings for this evaluation factor.

As previously noted, mobilization of TBMs to each tunnel portal site is also a significant constructibility and cost issue. Access roads and power must be supplied to tunnel access point. Additionally, the relative ease of spoil removal is influenced by the number of tunnel portals and availability of spoil areas. A large number of remote portals, therefore, resulted in a least favorable rating with respect to construction methods.

Earthwork
The high-speed train project, particularly in the Bakersfield-to-Sylmar segment, would include substantial excavation and grading, yeilding significant earthwork quantities. While borrow is not considered to be an issue within the Bakersfield-to-Los Angeles region, the removal and disposal of spoil, particularly from tunnels, is a significant consideration. Alignments with high earthwork quantities present construction challenges that result in a less favorable rating.

Structures
"Special" aerial structures, which are assumed to span other structures or reach in excess of 20 meters above grade, will require special accommodation during construction. Those alignments with a significant amount of special aerial structures were given a least favorable rating with respect to this factor.

Capital Cost

Alignment alternatives were ranked according to calculated capital cost, using the cost estimating methodology and unit prices provided in the Alignment/Station Screening Methodology. Options with lower total capital costs were ranked most favorable and those with higher costs less favorable. In preparing capital cost estimates, minor deviations to the established cost estimating methodology were made, as described below.

Earthwork and Related Items
Earthwork quantities for the Tehachapi crossings (Bakersfield-to-Sylmar) were determined from earthwork cross-sections. Two-to-one side slopes and intermediate benches were assumed for cut and fill slopes. At this level of design, no retaining walls were assumed. For at-grade construction, excavation to 3.25 feet (1 meter) was assumed for roadbed construction. Any earthwork required for at-grade construction within existing rail corridors was neglected, as was landscaping/habitat restoration or erosion control. Drainage facilities cost was calculated as 5 percent of site preparation, earthwork, and imported borrow costs.

Fencing
Fencing was assumed along the entire length of the alignments, excluding tunnels and aerial structures.

Railroad Relocation

It was assumed that railroad relocation would be required wherever the alignment shares a corridor with an existing operating railroad. This cost was reflected in the overall capital cost for each alignment option. Because railroad relocation presents other challenges, this issue was also considered in the ranking of right of way issues, as described below.

Building Items

For each alignment option, the "placeholder" cost values were used for Building Items, including terminal and site development/parking. For the Bakersfield-to-Sylmar Segment, suburban stations were assumed at Palmdale (except for Options 1 and 1A, which do not pass through the Antelope Valley) and Santa Clarita. For the Sylmar-to-Los Angeles Segment, an urban station was assumed at Burbank and a terminal station at Los Angeles Union Station. In rating the relative capital costs for alignment options, the Sylmar Station alternatives were not considered.

Except as described above in establishing costs for the alignment options, capital costs for individual station options were not calculated due to the lack of sufficient data to differentiate between costs of stations with similar features and/or locations. Rather, station options were rated against the capital cost category based on qualitative factors, such as probable ease of construction, significant earthwork or structures, and accessibility.

Tunnels

All tunnels within the region were considered to be constructed with the use of a tunnel boring machine (TBM). Two single-track tunnels were assumed for each alignment. For any tunnel longer than 8 miles (12 km) for which intermediate near-grade access would not be possible, a parallel evacuation tunnel was also assumed for each pair of single-track tunnels. The unit cost of an evacuation tunnel was assumed to be 75 percent of the cost of the primary tunnel pair.

The cost of a seismic chamber was provided for each tunnel crossing of a known fault. For "major" fault crossings, including the Garlock Fault and the San Andreas Fault, a unit cost of $50 million was used for the seismic chamber required for the tunnel pair. Seismic chambers at lesser faults, including the White Wolf/Wheeler Ridge Fault and the Santa Susana Fault near Sylmar, were assigned a unit cost of $25 million.

Tunnel portals were also considered to be a significant cost factor. The widened opening required to accommodate wind resistance at the tunnel opening, and the cost of mobilizing the tunnel boring machine, were estimated at $12 Million per portal.

Trenches

Open trenching is proposed within the Sylmar-to-Los Angeles segment. The unit cost of the trench was assumed to be twice that of a retaining wall. Track within trench limits was designated as at grade or slab track. Appropriate earthwork quantities were calculated and included in the estimate for trench excavation.

Miscellaneous Structures

Because their application has not yet been defined, crash walls and sound walls were neglected in this analysis. The exception is in the Bakersfield connection segments, where crash walls were applied at locations where bridges cross over the alignment, and sound walls were assumed adjacent to all built-up areas.

Utilities Relocation and Right of Way
Utility and right of way costs were calculated based on the entire alignment length, including tunnels and structures. Characterization (dense urban, urban, suburban, undeveloped) of these cost factors was made by reviewing USGS maps.

Right of Way Issues/Cost

In addition to inclusion in capital cost estimates, anticipated right of way issues and related costs were evaluated based on qualitative factors.

Adjacent Development
Right of way evaluation factors included density of adjacent development and local urbanization. Alignment and station options in close proximity to dense, established development were ranked lower. Potential for requireing right of way takes from multiple individual property owners, particularly residential owners, were scored least favorable.

Railroad Relocation
While ranking more favorable as continuous, linear rights of way, the use of existing railroad corridors would require the relocation of operating railroad tracks. The requirement for railroad relocation reflected negatively on the alignment ranking.

Regulated Rights of Way
Features such as national parks, preserves, and flood control channels, that serve to limit the unrestricted use of proposed right of way, were also considered in rating right of way issues. It was assumed that these regulated areas would require additional permitting, biological mitigation or habitat restoration and constrain construction operations. Options that pass through publicly regulated areas, therefore, were rated less favorably for this factor. These factors were considered less important where the alignment lies in tunnel rather than above ground.

2.2.2 Environmental Evaluation Criteria

The objectives related to the environment and the criteria used for evaluation are consistent with NEPA and CEQA. The environmental constraints and impacts criteria focus on key environmental issues that can affect the location or selection of alignments and stations.

To identify potential impacts for the alignments and station locations, a number of readily available resource agency-approved Geographic Information System (GIS)-compatible digital data sources were used along with published information from federal, state, regional, and local planning documents and reports. For evaluation of alignments and stations, right-of-way widths dictated by engineering requirements were utilized to identify the amount of area within each segment containing certain characteristics. Some environmental issues required using various buffer widths that extended beyond the conceptual right-of-way for the segments. Where noted, field reconnaissance was required to view on-the-ground conditions and to provide relative values of certain resources.

B. BAKERSFIELD-TO-LOS ANGELES ENVIRONMENTAL METHODOLOGY VARIANCES

Visual Quality Impacts

The potential impacts to visual quality of the High-Speed Rail (HSR) alignment alternatives and station locations were evaluated based on the anticipated changes in current views of first tier sensitive viewers.

Four basic criteria were used to evaluate the project options:

- The location of sensitive first tier viewers relative to the project.
- The length that sensitive residential uses occur along the alignments.
- The distance of the sensitive uses from the project features.
- The extent of the change in visual character that sensitive viewers will experience with the various alignment and station options.

Sensitive viewer groups include residential viewers, park users and students and faculty at school sites. These sensitive first tier viewer groups were identified, as well as the extent of residential uses along the alignments. An alignment with more adjacent residential uses was considered to have a more negative impact than alignments with fewer adjacent residential uses. For example, an option that has residential uses along five miles of the alignment would be rated more negatively than one with residences along 0.5 mile of the alignment. Impacts to schools and parks were quantified by the number of locations with first tier views. Alignments having a greater number were rated more negatively. Project features that cross through a campus or park were rated more negatively than project features adjacent to these sensitive uses.

The anticipated visual impacts were further screened by the distance of the project features from the sensitive viewers. Project features closer to sensitive viewers were rated as having as greater negative impact than features only visible at a greater distance.

Lastly, an evaluation was made of the extent of the change in the visual character that the sensitive viewer will experience. For example, an elevated structure proposed in a low density, rural area along a rural arterial would be a greater and more negative visual change than an at-grade rail segment adjacent to an existing freeway in a high-density, urban residential area. Similarly, project features proposed for undeveloped, rugged areas that will require extensive earthwork were rated more negatively than sites that require less earthwork. Features sited in areas proposed for Significant Ecological Area (SEA) status were rated as having a negative visual impact.

All of these criteria were evaluated to determine the ranking of alignments and stations relative to their compatibility with existing views.

Water Resources

The potential impacts to water resources of the High-Speed Rail (HSR) alignment alternatives and station locations were evaluated based on the number and sensitivity level of waters and potential wetland or riparian habitat resources crossed by or lying immediately adjacent to each alignment and station option. Drainages identified as "blue-line streams" on USGS topographic mapping were counted and the relative size of each feature was estimated based on the associated watershed area.

The potential sensitivity of water resources is rated as follows:

> *Low sensitivity* is indicated for minor tributary streams and small ephemeral drainage courses. These resources are still likely to be subject to the regulatory authority of the U.S. Army Corps of Engineers (Corps), the California Department of Fish and Game (CDFG), and the State Water Resources Control Board (SWRCB), if affected by the project. However, due to their small size and the limited volume of water carried, such "waters" are not likely to exhibit substantial riparian or wetland vegetation and requisite mitigation is anticipated to be minimal although minor impacts would occur due to the placement of culverts or diversions for at-grade crossings. Where such resources occur above or in close proximity to tunnel segments, it is unlikely that adverse impacts would occur, although the possibility cannot be ruled out.
>
> *Low to moderate sensitivity* is attributed to large tributary streams and small ponds or springs. Such waters potentially support some riparian vegetation and impacts could be considered significant. However, where bridges are proposed, it is assumed that adverse impacts to such resources will be avoided by strategic placement of abutments and footings such that direct impacts are avoided, and such crossings are not counted for the purpose of this comparative evaluation. The potential for adverse effects to occur to such resources above or near tunnel segments is still low, but is more likely than for minor tributaries.
>
> *Moderate to high sensitivity* is attributed to major tributaries, mainstem drainages, and large ponded areas. Larger streams and ponds generally contain substantial stands of riparian vegetation, portions of which may meet federal wetland criteria. Adverse effects to such areas would require substantial mitigation measures, and federal guidelines (Section 404(B)(1)) require that direct impacts be avoided to the maximum practicable extent.
>
> *High sensitivity* is attributed to large bodies of open water and extensive riparian habitat associated with major drainage courses.

In the City of Los Angeles and other urbanized areas (for example, Union Station Alternatives and the San Diego Approach Segments), station locations or route segments that may involve crossing channelized drainage courses, such as the the L.A. River, would not result in impacts to wetlands or riparian habitat and would cause only minimal effects, primarily involving potential reductions of water quality during construction, as these drainages do not generally exhibit significant biological resources in the areas of the proposed project alignments and station locations.

Floodplain Impacts

The alignments and station location were evaluated against GIS data for known 100 year and 500 year floodplains. Alignments and station locations subject to more serious flooding impacts were ranked scored lower than those with little or no flood hazard.

Threatened and Endangered Species

Threatened and endangered species analysis was based on information obtained from the California Natural Diversity Database (CNDDB), contacts with various resource agencies such as the U.S. Fish and Wildlife Service (USFWS), published scientific literature and personal communications with experts on individual sensitive species.

Locations of sensitive species and their habitats are subject to change as a result of seasonal variation, urbanization and other disturbances. Those alignments and station locations that would affect the greatest number of threatened and endangered species were ranked lower than those affecting fewer sensitive species.

Environmental Justice Impacts (Demographics)

Pursuant to Executive Order 12898, Federal Actions to Adress Environmental Justice in Minority Populations and Low-Income Populations, the total number of potentially affected persons and households was calculated within a 1,400-foot (427 m) buffer of alignments and stations. This was done using available 1990 Census data on a GIS database. Where portions of census tract/block areas were within the buffer zone a percentage of the qualifying individuals/households within the block was used based on the percentage of the area within the buffer zone. The greater the number of potentially affected individuals or households, the greater the potential impact and the lower the score for the alignment or station location.

Community and Neighborhood Impacts

Aerial photography and land use planning data,supplemented by field review was used to determine if communities and neighborhoods would be physically or psychologically divided by program elements. At-grade alignments were considered to constitute a physical division, while aerial structures were seen as a psychological division. Program elements with a greater potential to result in such impacts were given lower scores than those with less potential to create such effects.

Farmland Impacts

Alignments were compared to digital farmland mapping and those affecting a greater area of farmland were given lower scores. In some areas, farmland has been developed for other uses and was not counted in the analysis. The issue of pacel division was also factored into the review.

Cultural Resources

The potential impacts to cultural resources for the alignment alternatives and station locations were evaluated using two criteria. First, each element of the program was compared to the existing Project GIS database, and ranked as to potential impacts on known cultural resources. For example, each station location was compared to the GIS database, to determine if cultural resources had been recorded in or near the station location.

Second, given that the present GIS database is very incomplete relative to cultural resources, each element of the program was examined in relation to three additional factors known to archaeologists to increase the potential for discovery of previously unknown cultural resources. These are:

- proximity to major water sources
- geographic setting
- proximity to towns and cities

The first two factors are especially relevant to prehistoric cultural resources, while the last factor is relevant to historical cultural resources. These factors were considered based on the cultural resources consultant's professional experience in southern California, and a recognition of the statistical probability that sites are more likely to occur in these settings.

A comparison of two possible HSR alignments in the Antelope Valley, the Aqueduct Alignment versus the SR-138 Alignment, illustrates how this process was used. The Aqueduct Alignment lies at the base of the San Gabriel Mountains, a geographic setting more likely to encompass prehistoric sites than the flat open valley floor setting of the SR 138 Alignment. The Aqueduct Alignment is also more likely to encounter prehistoric resources due to several streams that flow out of the mountain front, making it an area more suitable to human habitation, versus the dry valley floor. But the SR 138 Alignment passes through a much larger portion of the cities of Palmdale and Lancaster, greatly increasing the probability that this route will encounter historical resources.

For Union Station Alternatives and evaluation of San Diego Approach Segments in the downtown area of the City of Los Angeles, any location or route has at least a moderate to high probability to encounter cultural resources. Again, geographic setting and urban neighborhood factors suggest that certain routes and locations have a higher probability for prehistoric and historical cultural resources. Alignments and station locations known to have or considered more likely to have cultural resources present were ranked lower than those less likely to encounter such resources.

Parks & Recreation/Wildlife

The potential impacts to parks and recreation areas and wildlife refuges of the alignment alternatives and station locations were screened based on proximity of parks and recreation or wildlife refuge resources to the program elements. As specified in the Task 1.5.2 Evaluation Methodology, visual impacts were considered to first row receivers, if parks were not directly impacted. Noise may also be a factor for some park and recreation facilities, but was not considered in this evaluation.

In the few cases where alignments cross existing park facilities, this was considered to have a high impact to the park resource, unless the crossing occurred primarily in tunnel. In the majority of cases, where the alignments pass near existing parks, the impact was considered in relationship to the park's present environment. For example, if a park setting was rural, or a quiet urban area, the impact of an alignment was considered to be moderate or high. In the case of a park located adjacent to existing railroad lines or freeways, addition of High-Speed Rail was considered a low impact. However, if the alignment element passed an existing facility on bridge/structure where previous rail or freeway use was at-grade, this was considered a moderate impact.

Soils/Slope Constraints

The screening of soils/slopes was performed in general conformance with the criteria set forth in the Screening Methodology. Soils were evaluated on the basis of both the soil and geologic formation data available on a statewide basis in addition to our general knowledge of characterisitics of each of these units. Soil shrink/swell, or expansivity, was evaluated in the project area by comparing alignments/stations with the extent of mapped expansive soil units/formations. Soil erodibility was similarly evaluated on the basis of extent and distribution of soil units, geologic formations, and experience. Slope stability was evaluated primarily on the basis of geologic formations with known low shear strength and/or propensity for landsliding. Slope steepness was not evaluated strictly on the basis of slope gradient as it was determined to be less representative of the constraint than the presence of low strength, poor performance geologic formations.

Seismic Constraints

Seismic constraints were also evaluated in general conformance with the recommended methodology. However, in lieu of solely analyzing seismic constraints on the basis of active fault crossings, historic seismicity and probabilistic seismic hazard assessment (PSHA) maps provided by the states' geologic agency (CDMG) were also used. Further, seismic constraints were subdivided into three basic potential hazards including: 1) presence of active fault crossings, 2) PSHA ground motion maps, and 3) liquefaction potential by comparing PSHA ground motion maps to formational maps to identify areas where younger, soft soils may coexist with high ground motion areas. Detailed CDMG maps depicting the seismic hazard zones are available for most of the Los Angeles Basin and San Francisco Bay areas but did not provide complete coverage for the project area and were thus not used. However, findings of those maps were compared to our independent conclusions and were generally consistent. Subsidence associated with groundwater withdrawal in the San Joaquin Valley was also addressed within seismic constraints as required. This evaluation was performed geographically based on available maps depicting extent, magnitude and timing of subsidence within the project area.

Hazardous Materials

Each alignment option and station option were evaluated based on the number of Comprehensive Environmental Response, Compensation, and Liability Information (CERCLIS), State Priority List (SPL), and State Clean-up List (SCL) sites that were close to proposed alignments or station locations. The alignment options and station options were also evaluated based on the number of Super Fund sites that were close to the proposed alignments or station locations. The ratings in the table were generally given as follows: CERCLIS, SPL, SCL < 20 = 4; CERCLIS, SPL, SCL $\geq$ 20 = 3; CERCLIS, SPL, SCL $\geq$ 50 = 2; CERCLIS, SPL, SCL sites and one Super Fund site = 2; CERCLIS, SPL,SCL sites and more than one Super Fund site = 1.